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WABASH RIVER BASIN COMPREHENSIVE STUDY COVERING RESERVOIR SITES--ETC(U)
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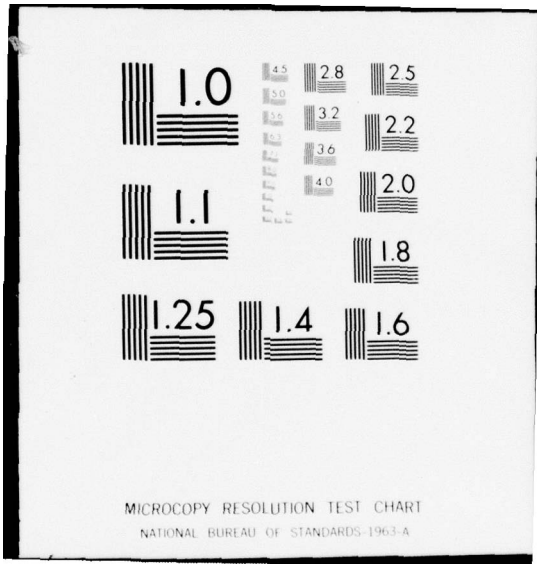
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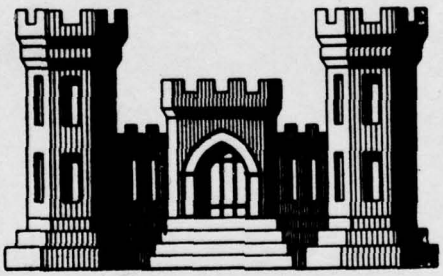
INTERIM REPORT NO. 2

WABASH RIVER BASIN COMPREHENSIVE STUDY

INDIANA, ILLINOIS AND OHIO

COVERING RESERVOIR SITES
ON
EMBARRASS RIVER, ILLINOIS
AND
CLIFTY CREEK AND PATOKA RIVER, INDIANA



PREPARED BY
U.S. ARMY ENGINEER DISTRICT, LOUISVILLE, Ky
CORPS OF ENGINEERS

JANUARY 1964

VOLUME I

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CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY

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INTERIM REPORT NO. 2
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SYLLABUS

A study of the Wabash River Basin to formulate a comprehensive plan of development for its water and related land resources that is consistent with present and projected future needs is under way with completion several years in the future. Studies have now progressed to the point, however, where the three reservoir projects recommended in this Interim Report have been identified as desirable elements of the comprehensive plan, and the present report has been prepared as a vehicle for their possible authorization for construction so that development of the Wabash River Basin will not be unnecessarily delayed.

This Interim Report proposes the development of Lincoln Reservoir on the Embarrass River in Illinois, Clifty Creek Reservoir on Clifty Creek in Indiana, and Patoka Reservoir on Patoka River in Indiana. Each of these reservoirs would be multiple-purpose in concept and other interested Federal agencies, as well as State agencies, have participated in their planning. All of the reservoirs would afford urgently needed flood control, provide opportunities for satisfaction of growing demands for water-associated recreation, and provide permanent pools which would enhance the existing sports fishery. In addition, Lincoln and Patoka Reservoirs would provide needed storage for water supply and improvement of downstream water quality. Each project is well justified, with annual benefits exceeding annual costs by ratios ranging from 1.6:1 to 2.2:1, and each individual project purpose is likewise justified. Local governments and public agencies in the states and areas affected preponderantly favor construction of the projects, except that individuals and interests whose properties are involved in land acquisition or damage considerations generally oppose the projects.

The District Engineer recommends construction of the three projects considered in this report at a total cost of $72,900,000 with the qualifications that, prior to construction, local interests agree to pay costs allocated to water supply in accordance with the Water Supply Act of 1958 as amended, and that local interests provide assurances that encroachments on downstream channels that would impair their discharge capacity and the flood control effectiveness of the reservoirs would not be permitted.

U. S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
830 West Broadway
Louisville, Kentucky 40201

CRLED-B 2 January 1964

SUBJECT: Interim Report No. 2 - Wabash River Basin Comprehensive Study; Indiana, Illinois and Ohio; covering reservoir sites on Embarrass River, Illinois, and Clifty Creek and Patoka River, Indiana

THRU: Division Engineer
U. S. Army Engineer Division, Ohio River
ATTN: ORDED-B
Cincinnati, Ohio

TO: Chief of Engineers
ATTN: ENGCW-PD
Department of the Army
Washington, D. C.

SECTION I - GENERAL

1. PURPOSE.

The purpose of this interim report is to present comprehensive plans of development for reservoir sites on the Embarrass River, Clifty Creek and Patoka River for one or more of the following needs: flood control, water supply, water quality control and low flow augmentation, water recreation and general conservation of water and related resources. This interim report, which is a part of the continuing Wabash River Basin Comprehensive Study, is submitted at this time to permit early consideration of the needs of the Wabash Basin areas which would be served by these reservoirs and of the feasibility of these reservoirs. The projects presented in this interim report are compatible with comprehensive development of the water and related land resources of the Wabash River Basin currently being developed and will permit an earlier start on the more urgently needed improvements to be recommended therein than would be the case if action was deferred until the comprehensive study was completed.

2. AUTHORITY.

There are 28 separate Congressional Resolutions which form the authority for the Wabash River Basin Comprehensive Study. This interim report covering reservoir sites in the Wabash River and White River Basins is submitted in partial response to the following two resolutions:

> "RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE HOUSE OF REPRESENTATIVES, UNITED STATES, That the Board of Engineers for Rivers and Harbors be, and is hereby, requested to review the reports on the Wabash River and tributaries in Ohio, Illinois and Indiana, published in House Document 100, 73rd Congress, First Session, and other reports with a view to determining whether improvement of the White River in Indiana in the interest of flood control and allied purposes is advisable at this time." (adopted: 20 April 1948)

> "RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act, approved June 13, 1902, be, and is hereby requested to review the reports of Chief of Engineers on the Wabash River and tributaries, Illinois and Indiana, submitted as House Document Numbered 100, Seventy-third Congress, First Session and other reports, with a view to determining whether any modifications of the recommendations contained therein are advisable at this time in the interest of flood control and the development and conservation of the water and related resources of the basin." (adopted: 6 May 1958)

In earlier partial response to the resolution adopted 6 May 1958, an interim report recommending "that the comprehensive plan for flood control and allied purposes in the Ohio River Basin be modified to include Lafayette and Big Pine Reservoirs" was completed by the Louisville District in March 1963 and is currently being reviewed by higher authority. This report has been designated Interim Report No. 1 of the Wabash River Basin Comprehensive Study and the proposed reservoir locations are shown on Plate 1.

3. SCOPE.

a. Scope of report. This report is an interim report of full survey scope, the same scope as the report under review (H. D. 100, 73rd Congress, 1st Session). It is concerned with the development of effective plans for comprehensive water resource development of reservoir sites on Embarrass River, Clifty Creek and Patoka River, all tributaries of the Wabash River.

b. Surveys, investigations and studies by U. S. Army Engineer District, Louisville. Preliminary examination of the areas considered in this report has been made by the District Engineer. Surveys, investigations, studies and activities have been as follows:

(1) Estimate of first costs and annual costs. Detailed estimates of costs of lands and damages, relocations, dams, recreation facilities and allied features were made for the reservoir sites considered herein. (Appendix A)

(2) Economic development and estimate of damages and benefits. This study describes the economic development of the basin and analyses damages expected to result from uncontrolled floods and benefits to be derived from flood control and other purposes over the economic life of the reservoirs considered herein. (Appendix B)

(3) Cost allocation and apportionment. This study selected the reservoir plans contained herein and allocated the cost of the projects considered to the various reservoir purposes. (Appendix C)

(4) Hydrology and hydraulics. These studies included the collection and formulation of data necessary to determine flood profiles and frequencies, stream flows, reservoir storage, control and design values for the reservoir sites considered herein. (Appendix D)

(5) Geology, soils and materials. These investigations and studies determined the site geology, foundation conditions and availability of construction materials for the dam and reservoir sites considered herein. (Appendix E)

c. Surveys, investigations and studies by State and other Federal agencies.

(1) Small watershed projects. A reconnaissance-type review of the Small Watershed Project potential of the sub-basins containing the projects considered herein was made by the United States Department of Agriculture, Soil Conservation Service. This review included appraisal of irrigation needs. (Appendix F, Exhibit F-1)

(2) Ground water appraisal. An evaluation of the ground water supply of the three basins covered in this report and adjacent area was made by the United States Department of the Interior, Geological Survey. (Appendix F, Exhibit F-2)

(3) Fish and wildlife. An analysis of the effect of the reservoir projects considered herein upon fish and wildlife resources of the project areas, and measures for enhancement of these resources, was made by the United States Department of the Interior, Fish and Wildlife Service. (Appendix F, Exhibit F-3)

(4) Recreation. An evaluation of the project areas recreational potential and an estimate of initial and ultimate annual attendance at recreational features for each project was made by the United States Department of the Interior, Bureau of Outdoor Recreation. (Appendix F, Exhibit F-4)

(5) Mineral production. An analysis of the effect of the reservoir projects considered herein upon the mineral resources of the project areas was made by the United States Department of the Interior, Bureau of Mines. (Appendix F, Exhibit F-5)

(6) Water supply and water quality control. This study was made by the United States Department of Health, Education and Welfare, Public Health Service to develop the need for and economic value of, incorporating water supply and water quality control storage into the plans for the reservoirs considered herein. (Appendix F, Exhibit F-6)

(7) Hydroelectric power. A study of hydroelectric power potentials of the reservoir projects considered herein was made by the Federal Power Commission. (Appendix F, Exhibit F-7)

(8) Hoosier National Forest impact report. The United States Department of Agriculture, Forest Service is responsible for preparing a report on impacts the Patoka Reservoir project will have on National Forest activities in the area. (Appendix F, Exhibit F-8)

(9) Hydrology and hydraulics studies by state agencies. The Indiana Flood Control and Water Resources Commission has prepared a report covering the Patoka Reservoir project which was used in formulating the Patoka Reservoir plan proposed herein. Data for the formulation of the Lincoln Reservoir plan of development were obtained from the 1963, State of Illinois Interim Report for Flood Control and Drainage Development, Embarrass River.

(10) Geology and foundation investigations. The Indiana Flood Control and Water Resources Commission, in conjunction with the Indiana Geological Survey, has accomplished geologic and foundation investigations at Patoka Reservoir site proposed herein, which are supplementary to those accomplished by the Corps of Engineers.

4. PRIOR REPORTS.

a. Report under review. The principal report under review is the comprehensive survey report on the Wabash River basin, entitled "Wabash River, Ohio, Indiana and Illinois," dated 22 January 1932, and published as House Document 100, 73rd Congress, 1st Session. It was the earliest comprehensive report of survey scope dealing with water resources of the Wabash River basin and it considered navigation, flood control, hydroelectric power, irrigation and allied development potentials. The findings presented in that report were that improvements of the Wabash River by the Federal Government for the purposes considered were not advisable at that time. Thirteen reservoir sites were considered in this investigation, which included the Wolf Creek site on the Embarrass River, located downstream from the Lincoln site considered in this report.

b. Other reports. Other reports pertinent to the areas under consideration and reviewed in preparation of this report are as follows:

Locality	House document number and date submitted	Improvements considered	Recommendations
Ohio River	House Document No. 306, 74th Congress, 1st Session submitted 14 August 1935	Comprehensive plan for navigation, flood control, hydroelectric power and irrigation	Further study by Chief of Engineers and local interests.
Comprehensive Flood-Control Plan for Ohio and Lower Mississippi Rivers	House Flood Control Committee Document No. 1, 75th Congress 1st Session, submitted 28 April 1937	Review of comprehensive plan presented in House Document No. 306	A system of flood control reservoirs on tributaries of Ohio River; 8 located in Wabash basin including Wolf Creek site on Embarrass. River
Comprehensive Flood-Control Plans and Works for Reservoirs, Levees and Floodwalls	House Flood Control Committee Report No. 2353, 75th Congress, 3rd Session, submitted 13 May 1938	Restudy and revision of comprehensive plan presented in House F. C. Committee Document No. 1	Ohio River basin plan included eight local flood protection projects and five reservoirs in Wabash River basin. Wolf Creek site, Embarrass River, included.
Wabash River and Tributaries, Indiana and Illinois	House Document No. 197, 80th Congress, 1st Session, submitted 1 April 1947	Comprehensive plan for flood control in Wabash River basin. Two reservoir plans studied	Construction of 21 levee and local protection projects and one channel improvement project. Deletion of authority for 3 reservoirs including Wolf Creek Reservoir, Embarrass River.
Headwater Reservoirs, Wabash River, Indiana	House Document No. 435, 84th Congress, 2nd Session, submitted 14 June 1956	Flood control plan for upper reach of Wabash River, Logansport-Huntington	Construction of three reservoirs. Deletion of authority for local protection projects at Logansport, Peru and Wabash, Ind.

5. DESCRIPTION.

a. Wabash River Basin. The Wabash River basin is an approximately oval drainage area of 33,100 square miles, 319 lying in western Ohio, 8,563 in eastern Illinois, and 24,218 in Indiana. The length of the basin is about 285 miles and its maximum width about 190 miles. The Wabash River rises near Celina, Ohio, flows northwesterly 67 miles to Huntington, Indiana, thence generally west and southwest 312 miles to the confluence of the White River, its major tributary, and then continues southwesterly 96 miles to join the Ohio River, at a point 133 miles above its junction with the Mississippi River, for an over-all length of about 475 miles. A map of the basin and its tributaries are shown on Plate 1. Further description in this report is limited to the three tributaries, Embarrass River, Clifty Creek and Patoka River, on which reservoir sites are considered herein.

b. Embarrass River Basin - Lincoln Reservoir. The Embarrass River basin lies entirely within the state of Illinois. The drainage area of this tributary of Wabash River, the third largest in the Wabash Basin, is long and narrow, with a length of approximately 105 miles and a fairly uniform width of about 25 miles. Total drainage area is 2,438 square miles, of which 915 square miles are above the Lincoln dam site considered and described elsewhere in this report. The Embarrass River rises in the central part of Champaign County, near Urbana, Illinois, flows in a southerly direction through Douglas, Coles, and Cumberland Counties to the center of Jasper County, thence in a general southeasterly direction to the north edge of Richland County, the southwest corner of Crawford County, and across Lawrence County to its junction with the Wabash River at about 122 miles above the junction of the Wabash and Ohio Rivers, or six river miles below Vincennes, Indiana. The Embarrass River is 185 miles long with many crooks and long tortuous bends. The largest tributary, North Fork Embarrass River, enters the Embarrass River downstream from Lincoln dam site at river mile 103, and drains an area of 325 square miles. From the mouth to mile 63, the main channel slopes vary from 1 to 1.5 feet per mile. Between mile 63 and mile 169, the slope is about 1.6 feet per mile and averages about 7 feet per mile for the remaining upper reaches of the river. In the reach below mile 100, the average depth from mean low water to bank line is approximately 15 feet and from low water to maximum high water, about 22 feet. The average channel width in this reach is approximately 200 feet and the total valley width at elevation of maximum high water, about 1.5 miles. The average channel capacity from the mouth to mile 101 is about 7,000 cubic feet per second or about 13,900 acre-feet per day. Bankfull stage is exceeded several times per year. Due to the topographic and drainage features of the watershed, run-off from moderate to severe rainfall results in frequent medium to high-stage flows of long duration.

In its upper reaches, the Embarrass River is a sluggish prairie stream fed by numerous low gradient tributaries. Near the Coles-Douglas County line, the river drops abruptly to form a steep-walled, V-shaped valley 50 to 70 feet below the adjacent upland which extends south for approximately 50 miles. In Cumberland County and throughout the Illinoian glacial drift area the channel occupies a broad flat-bottomed valley with steep valley walls rising sharply to the upland. The river throughout its course occupies a sharply defined valley abruptly below the upland. The topography varies from hilly terrain in the upper reaches to a relatively level terrain in the lower reaches. The valley bottom width varies from 0.5 mile to 2.5 miles and averages about 1.3 miles from the mouth to mile 91.7. From mile 91.7 to mile 170, which includes the Lincoln Reservoir area, valley widths range from 300 feet to 3,000 feet and average 1,300 feet.

c. Clifty Creek Basin - Clifty Creek Reservoir. Clifty Creek is a tributary of the East Fork White River. It is formed in Decatur County, Indiana, near the city of Sandusky, Indiana, by the juncture of its three upper branches, the North Branch, the Middle Branch, and the South Branch. From Sandusky the stream flows in a southwesterly direction across Decatur County and continues in the same general direction to its junction with the East Fork of the White River in the middle of Bartholomew County, about three miles south of Columbus, Indiana, and about 187 river miles above the junction of the East Fork White River and the White River. Clifty Creek watershed is about 40 miles in length with an average width of from four to five miles. The total length of the stream is about 25 miles. The total drainage area is about 200 square miles, of which 140 square miles are above the dam site proposed herein.

The topography of the watershed is gently rolling with elevations varying between 590 feet at the mouth to 1,000 feet in the upper reaches. The reservoir site is just below the mouth of Fall Fork, 18.4 miles above the mouth of Clifty Creek, and about 1.5 miles downstream from Hartsville, Indiana. In the project area both Clifty Creek and Fall Fork, for a distance of about 3,000 feet above its confluence with Clifty Creek, flow through narrow, steep-sided valleys with numerous, short, intermittent, high-gradient tributaries entering from the surrounding farmland. Upstream of this deep-valleyed area, Fall Fork and Middle Fork form a wide rectangular area with both of these smaller streams having cut their channels to the limestone bedrock. On Fall Fork, undercutting of a shale layer has produced a 10-foot high falls about 1.8 miles above its mouth. Much of the flood plains of both Clifty Creek and Fall Fork are cleared and support grain farming, dairying and livestock production. Wooded areas exist on the steep valley sides and along the immediate stream banks.

d. Patoka River Basin - Patoka Reservoir. The Patoka River Basin lies in southwestern Indiana. The drainage area is long and narrow with the long axis reaching halfway across the state in a generally east-west direction. The basin is about 80 miles in length with short side tributaries included in a basin width of not more than 12 miles. Over-all drainage area is about 865 square miles of which 168 square miles are

above the dam site proposed herein. The Patoka River rises in southeastern Orange County near Valeen, Indiana, flows in a westerly direction through Dubois, Pike and Gibson Counties to the Indiana State line and its junction with the Wabash River at Mile 94.6, about one mile below the mouth of the White River. Throughout the lower two-thirds of its course, the Patoka River parallels the White River and its East Fork at an average distance of about 10 miles to the south. The Patoka River is about 133 miles long and flows through many long tortuous bends. Throughout most of its course, it is a sluggish, meandering stream in a flat valley with an average slope of about 0.8 foot per mile. In the Wabash River backwater area below the town of Patoka, the river has a stream length of 17.5 miles in a valley length of nine miles. Between the towns of Winslow and Patoka the stream gradient averages about one foot per mile. The channel has been straightened downstream from Winslow to a point about three miles above the Princeton Water Works. From the source of the stream to the vicinity of Jasper, the valley is generally narrow, averaging less than a mile in width. From Jasper to the Wabash River backwater area near Patoka, valley widths range from 0.4 mile to 2.5 miles and average about one mile. In this reach there are a number of wide flat pockets interconnected by much narrower reaches. The valley is bordered by hills which rise on gentle or steep slopes, depending on the locality, to generally about 100 feet above the valley floor. There are several low divides in the bordering uplands. The topography in the upper half of the basin, above the vicinity of the Pike-Dubois County line, is fairly rugged and the hill slopes are short, irregular and face in all directions. The topography of the lower half of the basin, except for the hills north and west of Princeton which are rough and uneven, is generally rolling and slopes are fairly long and even. Elevations in the Patoka River basin vary from about 400 feet mean sea level (M.S.L.) mouth to above 750 feet M.S.L. in its upper reaches .

SECTION II - ECONOMIC DEVELOPMENT

6. ECONOMIC BACKGROUND OF THE WABASH RIVER BASIN.

Population growth with its attendant development of economic activities in the Wabash River Basin began early in the Nineteenth Century. Initially small population centers were formed as clusters along streams and a number have developed commercial and industrial importance. But early settlers generally had strong interests in land and the independence of a rural way of life and agriculture came to be developed as the principal economic activity. Those interests influenced the development of the region's agriculture base and attracted and retained other settlers with similar interests.

While natural waterways provided the first movement of persons and things into the Basin, the construction of canals and subsequently the building of railroads during the Nineteenth Century facilitated the economic development.

While the Wabash Basin promises to continue in importance as a producer of agricultural products, its economic future will be enhanced by the development of commercial and industrial activities.

7. DEVELOPMENTAL DIFFERENCES BETWEEN WHITE AND WABASH BASINS.

As evidenced by population and employment data, the White River Basin portion of the Wabash River Basin is becoming more industrialized and more urbanized. The percent of the population residing in urban areas of the White River Basin was 62.1 in 1960, but is projected to increase to 72.8 in 2010. The percent of the population residing in urban areas in the Wabash River Basin, exclusive of the White River Basin, was 49.7 in 1960, and is projected to account for a 60.4 percent share in 2010. Employment increases in trade, in services, and in manufacturing, are therefore more evident in the White River portion of the Wabash River Basin.

Growth in manufacturing and in retail sales is indicated by the following schedule:

	Value Added by Manufacturing 1954 ($1,000)	Value Added by Manufacturing 1958 ($1,000)	Total Retail Sales 1954 ($1,000)	Total Retail Sales 1958 ($1,000)
Wabash Basin in Illinois	$ 171,803	$ 215,087	$ 506,076	$ 579,549
Wabash Basin in Indiana[1/]	539,190	674,291	816,421	925,683
Total	$ 710,993	$ 889,378	$1,322,497	$1,505,232
White Basin, Indiana	1,586,675	1,816,163	1,759,169	1,997,993
Total, Wabash Basin	$2,297,668	$2,705,541	$3,081,666	$3,503,225

Between the business-census years of 1954 and 1958 the growth in value added by manufacturing was 18 percent and the growth in retail sales was 14 percent for the total Wabash Basin. It is to be noted that the contributions of the White Basin were substantially greater in absolute numbers, although percentage gains that can be determined from the above schedule will indicate that the Wabash Basin exclusive of the White Basin had a faster rate of growth during that 4-year period.

A more significant indication of development in the two sub-basins is reflected by projected population. Preliminary reports from an economic survey of the Ohio River Basin by the A. D. Little Company project an increase in population of 90.3 percent for the White River sub-basin by the year 2010. The projected increase for the Wabash Basin, exclusive of the White River Basin is 51.3 percent for the same period.

[1/] Exclusive of White River Basin.

8. DEVELOPMENT TRENDS.

The population of the Wabash River Basin grew from 2,363,400 in 1930 to 3,145,300 in 1960, an increase of about 33.1 percent for the three decades. Preliminary projections provided by the A. D. Little Company study indicate that the total population for the Basin will reach a total of 5,454,600 in the year 2010. This is a 73.4 percent increase over the 1960 count, and would indicate an annual growth rate of 1.47 percent.

It is well established in economics that communities which can provide increasing employment opportunities, have a population growth potential. In the free enterprise system, factors of production (labor is one such factor) move in response to demand. Communities that can maintain employment opportunities on a continuing basis will experience increases in their populations. There is a definite relationship between projected populations and projected employment counts in a given area. Of the 18 counties situated in the State of Illinois, Champaign, Coles, and Vermilion Counties provided almost 20 percent of the employment in the subarea in 1960. These three counties also accounted for about 20 percent of the population in 1960. The proposed Lincoln Reservoir would be located in Coles and Cumberland Counties and would also benefit Crawford, Jasper, and Lawrence Counties which have a down stream location. Similar situations exist to smaller scale in the State of Indiana with reference to the proposed Clifty Creek and Patoka Reservoirs.

A significant indication of economic change in the Wabash Basin is in the increasing productivity of its agriculture which has been accompanied by substantial decreases in its agricultural employment. Dollar value of farm production sales increased from $672.9 million in 1949 to $856.9 million in 1959. In a roughly comparable period (1950 to 1960) the employment in agriculture in the Wabash Basin decreased from 150,900 to 97,200. Based on that census data, the productivity per worker in agriculture increased from $4,459. to $8,816.

Bituminous coal and petroleum products are the most important mineral products in the Basin. Other mineral products are sand, gravel, sandstone, limestone, clay, natural gas and gypsum.

Total employment is increasing in the Basin and while decreases are being reported in agriculture and in mining, employment is increasing in construction, transportation, wholesale and retail trade, finance, insurance, and real estate, business and personal services, and in manufacturing. Most significant employment increases have been reported in wholesale and retail trade, business and personal services, and in manufacturing. These activities are conterminous with urban development and presumably will increase in the future as urban population increases.

Manufacturing is a basic employment which sets in motion demands that can be served by business activities in construction, transportation, services, and in finance. Growth in retail trade is one indication of a general betterment in the standard of living in the Wabash Basin. It is also an indication of a growing capacity for consumption of goods and services produced in the Basin.

From the standpoint of present economic development the Wabash Basin is an agricultural carpet studded with small, medium, and a few large cities. This diversification of interests would appear to be a factor pointing toward the continued economic growth and importance of this geographic area. With an agricultural base permitting the production of a variety of crops, important natural resources, good transportation potential, available industrial plant sites, and proximity to both the industrial developments along the main stem of the Ohio River and the Great Lakes industrial complex, the economic role of the Wabash Basin should increase in importance. A more detailed discussion of Economic Development is presented in Appendix B, Section I.

SECTION III - METEOROLOGY AND HYDROLOGY

9. CLIMATOLOGY.

In general, the climate of the Wabash River basin is temperate, having neither severe nor protracted winters, nor long periods of abnormally high temperatures during the summer season. Moderate cloudiness and windiness are accentuated by occasional tornadoes. High humidity and frequent temperature changes with considerable rainfall, usually well distributed throughout the year, are characteristic of the portion of the Wabash basin considered herein. Convective storms of intense precipitation but of short duration are prevalent during the summer months. Accumulation of climatological data for periods of record varying from a few years to over 100 years are in existence. The only first order U. S. Weather Bureau station presently within the Wabash River basin is at Indianapolis, Indiana. The mean annual precipitation for the Wabash River basin is about 40 inches. Snow rarely remains on the ground for more than a few days at a time and, in general, snowfall over the basin is a small contributing factor to floods. The average annual snowfall for the area is about 20 inches. The mean temperature of the Wabash River basin is about 52 degrees Fahrenheit. Maximum and minimum recorded temperatures at Vincennes, Indiana, which is considered typical of the area, are 111 and -19 degrees. The maximum wind velocity recorded at Terre Haute, Indiana, for an approximate one minute duration, is 66 miles per hour.

10. RUNOFF AND STREAM FLOW.

The average annual runoff for the Wabash River basin is about 12 inches. Pertinent data for stream gages, runoff, and stream flow, which are considered representative of this portion of Wabash basin,

are given in tables 1 and 2. A minimum annual runoff of 3.43 inches and a maximum of 28.59 inches occurred on the Wabash River at Mt. Carmel, Illinois. A minimum annual runoff of 0.38 inches and a maximum of 26.09 inches occurred on the Embarrass River at Ste. Marie, Illinois. A minimum annual runoff of 2.47 inches and a maximum of 29.97 inches occurred on the East Fork White River at Seymour, Indiana. A minimum annual runoff of 2.77 inches and a maximum of 36.33 inches occurred on the Patoka River at Princeton, Indiana. It was necessary to develop flows for all three reservoir project studies, by application of effective rainfall to unit hydrographs for some periods. Table 1 gives drainage area, period of record, essential flood stage, and discharge maximum, minimum and mean values, for all pertinent gages. Table 2 gives the flood runoff dates, estimated peak stage and discharge, and also includes the volume of storm runoff expressed in acre-feet and inches. Details and analyses of significant data are given in Appendix D, Hydrology and Hydraulics.

TABLE 1

PERTINENT DATA ON STREAM GAGES

Location	Elev. of gage zero (ft. m.s.l.)[d]	Drainage area (sq.mi.)	Flood stage (ft.)	Period of record (years)	Discharge		
					Maximum (c.f.s.)	Mean (c.f.s.)	Minimum (c.f.s.)
Wabash River at Mt. Carmel, Ill.	371.46	28,600	17	35	428,000	26,980	1,620
Patoka River near Princeton, Ind.	394.09	823	14	28	18,700	1,019	0
Patoka River at Jasper, Ind.	446.19	262	8[b]	14	16,000[a]	381	0
Patoka River near Ellsworth, Ind.	477.00	171	c	1	18,000[a]	190	0.3
White River at Petersburg, Ind.	400.00	11,139	16	35	235,000[a]	11,570	553
East Fork White River at Shoals, Ind.	442.25	4,954	25	48	160,000	5,434	44
East Fork White River at Seymour, Ind.	550.67	2,333	14	35	120,000[a]	2,411	84
Embarrass River at Ste. Marie, Ill.	446.75	1,513	18	51	44,800	1,219	1

a Estimated or obtained by Corps of Engineers and local resident information
b Damage stage reading
c Not available
d 1929 General Adjustment

TABLE 2

RUNOFF AND STREAM FLOW DATA

Runoff date		Estimated peak		Volume of storm runoff	
Month	Year	Stage	Discharge	(Acre-Feet)	(Inches)
		Wabash River at Mt. Carmel, Ill.			
Dec	32 - Jun 33	26.1	232,000	23,078,000	15.13
Dec	36 - Jun 37	25.1	285,000	17,631,500	11.56
Jan -	Jul 39	23.2	197,000	15,159,700	9.94
May -	Jul 43	25.2	305,000	8,615,100	5.65
Feb -	Jul 45	22.0	162,000	15,422,900	10.11
Feb -	Jun 48	22.0	162,000	9,082,800	5.95
Dec 48 -	Jul 49	23.8	236,000	19,777,700	12.96
Dec 49 -	Jul 50	27.1	288,000	30,212,300	19.81
Nov 50 -	Jun 51	24.1	164,000	18,647,700	12.23
Nov 51 -	Jul 52	22.6	127,000	18,967,000	12.43
Jan -	Aug 57	23.2	138,000	15,167,800	9.94
Nov 58 -	Jul 59	24.1	174,000	16,116,100	10.57
Feb -	Jul 61	26.4	250,000	14,594,000	9.57
		Patoka River at Princeton, Ind.			
Feb -	Jul 45	21.1	15,400	948,800	21.82
Dec 48 -	Apr 49	18.8	9,700	840,700	14.30
Dec 49 -	Jun 50	20.0	12,600	1,253,700	28.84
Nov 50 -	May 51	16.6	5,600	1,006,700	23.16
Nov 51 -	Apr 52	17.4	6,680	828,300	19.06
Jan -	Mar 59	18.7	9,490	282,300	6.49
Feb -	May 61	20.6	12,900	546,100	12.56
		East Fork White River at Seymour, Ind.			
Dec 32 -	Jun 33	10.9	40,100	1,902,200	15.31
Dec 36 -	Jun 37	19.5	66,600	1,787,700	14.39
Jan -	Jul 39	17.7	36,200	1,293,600	10.40
Dec 49 -	Jul 50	18.7	54,000	2,588,600	20.83
Jan -	Aug 57	17.9	33,400	1,304,900	10.49
Nov 58 -	Jun 59	19.4	62,100	1,342,500	10.80
Feb -	Jun 61	18.9	59,400	1,335,600	10.75
		Embarrass River at Ste. Marie, Ill.			
Dec 32 -	Jun 33	21.4	22,500	1,079,500	13.38
Dec 36 -	May 37	20.8	17,300	759,100	9.41
Jan -	Jul 39	21.5	23,900	833,500	10.33
May -	Jun 43	23.4	32,000	615,700	7.63
Feb -	Jul 45	21.6	25,500	883,700	10.95
Feb -	Jun 48	22.3	29,200	503,400	6.24
Dec 49 -	Apr 50	25.0	44,800	1,228,800	15.23

11. FLOODS OF RECORD.

The valleys in a large part of the Wabash River Basin are broad and flat with the result that agricultural damages in the wide flood plains are a major factor in the determination of total loss suffered from floods. Great flood destruction also occurs to towns located along the banks of the Wabash River and its tributaries. The principal cause of floods in the Wabash River Basin is excessive rainfall. Snow melt, the release of ground water by thawing or the saturated condition of the ground at the time rainfall occurs, aggravates flood conditions by increasing runoff. Floods have occurred in every month of the year but those of summer and fall ordinarily have less areal coverage than those of winter and spring. Since the August 1875 high water, all major floods have occurred in the winter and spring months. The March 1913 flood was the most devastating runoff period in the Wabash River Basin history. After this flood many new stream gaging stations were established with the result that more and better flood data are now available. Accordingly, since 1913 the five floods of greatest magnitude from the standpoint of areal coverage, combined with maximum stages for the portion of the Wabash Basin considered herein, in descending order of magnitude are May 1943, January-February 1950, May 1933, March 1939, and January 1930. Detailed records of floods are given in Appendix D, Hydrology and Hydraulics.

12. STANDARD PROJECT FLOOD.

The results of the computations of the standard project floods for the various reservoirs studied are shown in Appendix D. The procedure adopted was in accordance with Civil Works Engineer Bulletin No. 52-8, dated 26 March 1952, and titled, "Standard Project Flood Determinations." The standard project floods thus determined represent flood discharges that would be expected from an extremely severe combination of meteorologic and hydrologic conditions considered reasonably characteristic of the region involved. The volumes of the standard project floods for various reservoirs herein considered are given in table 3. The adoption of lesser volumes of flood control storage than those indicated for the standard project floods was influenced by upstream conditions and the general topography of the land near the damsite.

13. PROBABLE MAXIMUM FLOOD.

The volumes of the probable maximum floods and adopted flood control storages for the reservoirs found desirable in this report are given in table 3. The probable maximum rainfall for all reservoirs was taken from the U. S. Weather Bureau Hydrometeorological Report No. 33, dated April 1956. The hydrographs of the probable maximum inflow into the pools of the various reservoirs were determined by application of effective rainfall to the unit hydrographs of runoff in critical time relation. The details of spillway floods are shown in Appendix D, Hydrology and Hydraulics. The floods thus derived were the basis of spillway design and the selection of top of dam elevation necessary to insure structural safety under extreme flood conditions.

14. FLOOD REDUCTIONS.

The stage reduction afforded by Lincoln, Clifty Creek and Patoka Reservoirs at downstream points was based on reductions estimated in addition to those attributable to reservoirs completed, under construction and undergoing advance planning. The number of floods routed through Lincoln, Clifty Creek and Patoka Reservoirs are respectively 14, 7, and 7 in accordance with their schedules of regulations. The reservoir holdouts thus determined were then routed downstream by use of the coefficient method of routing in order to evaluate the reductions at downstream damage points. The modified frequency curves determined from the reductions, which are indicated by the above-routed floods, are the basis for annual benefits that are obtained from the reservoirs. Appendix D, Hydrology and Hydraulics, indicates in detail the reductions at downstream points afforded by the reservoirs.

TABLE 3

PROBABLE MAXIMUM, STANDARD PROJECT, MODIFIED STANDARD PROJECT, AND ADOPTED FLOOD CONTROL STORAGE

Item	Reservoir		
	Lincoln	Clifty Creek	Patoka
Drainage area (sq. mi.)	915.0	139.3	168.0
Volume of probable maximum flood			
(acre-feet)	741,700	110,530	187,710
(inches runoff)	15.20	14.82	20.95
Volume of standard project flood			
(acre-feet)	542,165	94,467	131,263
(inches runoff)	11.11	12.67	14.65
Adopted flood control storage			
(acre-feet)	477,000	48,560	144,100
(inches runoff)	9.77	6.51	16.08
Volume of standard project flood modified by reservoir			
(acre-feet)	65,165	45,907	0
(inches runoff)	1.34	6.16	0

SECTION IV - WATER RESOURCES PROBLEMS AND NEEDS

15. FLOOD PROBLEMS.

a. Extent and character of flooded area.

(1) General. The overflow areas affected by the three reservoirs considered in this interim report are:

Reservoir	Stream	Mile to Mile
Lincoln	Embarrass River	0.0 to 103.2
	Wabash River	0.0 to 124.2
Clifty Creek	Clifty Creek	0.0 to 18.4
	East Fork White River	51.6 to 238.3
	White River	0.0 to 51.6
	Wabash River	0.0 to 95.6
Patoka	Patoka River	0.0 to 118.3
	Wabash River	0.0 to 94.5

The total flood plain area, about 614,000 acres, is chiefly agricultural and comprises approximately 50 percent of the overflow area of the Wabash River basin. Presented in the following paragraphs is a brief discussion of the stream areas studied with a summary of flood plain developments presented in table 4. Additional data on development are given in Appendix B.

(2) Wabash River. The area subject to inundation along the portion of Wabash River studied by this report comprises about 320,000 acres of principally agricultural lands. Of the total area about 252,000 acres, or 79 percent, is in cultivation. Farm developments are scattered throughout the flood plain on ridges or knolls, or along the edge of the flood plain above low and medium stage flooding. Generally, the upstream two-thirds of the study area is more highly developed than the downstream one-third, which is subject, also, to frequent Ohio River backwater flooding. There are two urban areas that are subjected to partial inundation. Over 300 miles of roads and railroads cross or traverse the flood plain. There are six existing levees, one constructed by the Corps of Engineers and five constructed by local interests, that offer partial protection to about 65,000 acres of agricultural lands in the study area of the Wabash River. In addition, two Corps of Engineers' levee projects, Levee Unit 5, which is under construction, and Mount Carmel Local Protection Project, Illinois, which is in the advanced design stage, will afford protection to portions of the area. The total value of all properties along the Wabash

River below the Embarrass River, excluding the property protected by the Mount Carmel protection project, is estimated to be $102,000,000.

(3) Embarrass River. The flood plain area of the Embarrass River below the proposed Lincoln Reservoir consists of about 80,000 acres of land, of which about 68,000 acres, or 85 percent, are in cultivation. The stream valley varies in width from 300 feet to about 13,000 feet and averages about 4,000 feet. Portions of two urban areas, Newton and Lawrenceville, Illinois, are within the flood plain. Three major highways, U. S. 50, 150 and 40, and four railroads cross the Embarrass River. In addition, many miles of metal surface and gravel roads traverse the valley. Five agricultural levees, of a total of eight locally constructed levees, offer some degree of protection to about 18,500 acres of agricultural lands and improvements. The remaining three levees offer negligible protection. The estimated value of property within the study area of the Embarrass River is $23,000,000.

(4) White and East Fork White Rivers and Clifty Creek. The areas effected by Clifty Creek Reservoir are diverse and varied in character. In the relatively short reach of Clifty Creek (18.4 miles from its mouth to the dam site) the stream is narrow and the flood plain averages about 2,000 feet in width. A residential sub-division, a suburb of Columbus, Indiana, consisting of about 110 residential units, lies near the stream. With the exception of fences, outbuildings, and several road crossings, there is little other development in the overflow area. Along the East Fork of White River the flood plain averages about 10,000 feet in width in the area below Clifty Creek, narrows to about 2,600 feet in width in the middle reaches and widens to about 7,000 feet along the lower East Fork and White River. Many farm improvements, including fences and barns, are in the overflow area. Portions of seven urban areas are subjected to flooding. Numerous highways and roads lie in or cross the flood plain with the most important of these being US I-65, US 31, 50, 231 and 41. There are nine railroad crossings. The total value of properties in the flood plain between the proposed Clifty Creek dam site and the Wabash River is estimated to be about $63,000,000.

(5) Patoka River. The Patoka River overflow area comprises about 59,000 acres of agricultural lands, of which about 42,000 are in cultivation. The flood plain varies in width from about 6,000 feet in the lower reaches to about 1,200 feet in the vicinity of Ellsworth and averages about 4,000 feet. Agricultural development consisting of complete farm units are largely located along the edge of the flood plain. Many areas maintain fences and drainage ditches. Four urban areas, the largest of which is Jasper, Indiana, are partially subjected to inundation. There are thirty-two highway and ten railroad bridges that cross the Patoka River in the study area. The most important of the highway crossings are U.S. 41 and 231 and Indiana State Highway 57. One levee, the locally built Columbia Levee, offers

minor protection to 700 acres of agricultural land. The total value of properties below Patoka Reservoir is estimated to be about $25,000,000.

(6) Summary. Summarized in table 4 are the estimated value of properties, by stream reaches, studied in connection with this report.

TABLE 4

TYPE AND VALUE OF DEVELOPMENT BY STREAM REACHES

Stream and reach	Mile to mile	Type of development and value (1963)							
		Rural		Urban		Transportation		Levees	
		Area (acres)	Value ($1,000)	Number	Value ($1,000)	Routes (miles)	Value ($1,000)	Number	Value ($1,000)
Wabash River									
W-1	0.0 - 40.0	108,000	$ 23,182	2	$ 1,079	102	$ 7,619	2	$ 103
W-2	40.0 - 94.5	114,000	24,452	-	(1)	126	9,464	1	454
W-3	94.5 -124.2	99,700	23,801	-	-	82	6,162	3	5,830
Total Wabash River		321,700	$ 71,435	2	$ 1,079	310	$23,245	6	$6,387
Embarrass River									
EM-1	0.0 - 63.8	65,000	$ 14,011	2	$ 1,083	100	$ 3,051	5	$ 500
EM-2	63.8 -103.2	14,900	3,396	-	-	37	911	-	-
Total Embarrass River		79,900	$ 17,407	2	$ 1,083	137	$ 3,962	5	$ 500
White River									
WH-1	0.0 - 51.6	24,200	$ 5,447	1	$ 1,708	80	$ 3,398	-	$ -
East Fork White River									
EW-1	51.6 - 111.9	30,200	$ 7,080	1	$ 1,104	66	$ 2,090	-	$ -
EW-2	111.9 - 142.9	9,200	1,963	-	-	4	126	-	-
EW-3	142.9 - 183.7	15,600	3,972	-	-	20	630	-	-
EW-4	183.7 - 238.3	71,600	21,093	5	7,732	151	4,782	-	-
Total East Fork White R.		126,600	$ 34,108	6	$ 8,836	241	$ 7,628	-	$ -

TABLE 4 (Cont'd)

TYPE AND VALUE OF DEVELOPMENTS BY STREAM REACHES

Stream and reach	Mile to mile	Type of development and value (1963)							
		Rural		Urban		Transportation		Levees	
		Area (acres)	Value ($1,000)	Number	Value ($1,000)	Routes (miles)	Value ($1,000)	Number	Value ($1,000)
Clifty Creek									
CC-1	0.0 - 18.4	3,400	$ 1,151	1	$ 728	5	=$ 84	-	$ -
Total White and East Fork White Rivers and Clifty Creek		154,200	$ 40,706	8	$11,272	326	$11,110	-	$ -
Patoka River									
P-1	0.0 - 17.5	9,000	$ 1,449	-	$ -	-	$ -	-	$ -
P-2	17.5 - 34.6	15,300	2,494	1	28	15	640	-	-
P-3	34.6 - 54.8	9,600	1,123	1	62	10	540	1	16
P-4	54.8 - 62.2	3,200	364	-	-	2	170	-	-
P-5	62.2 - 81.1	9,500	1,273	-	-	11	240	-	-
P-6	81.1 -106.0	9,000	1,080	1	13,362	12	340	-	-
P-7	106.0 -118.3	3,000	392	1	1,141	6	370	-	-
Total Patoka River		58,600	8,175	4	14,593	56	2,300	1	16
Grand Total		614,400	137,723	16	28,027	829	40,617	12	6,903

(1) Excludes Mt. Carmel, Ill., authorized for local protection.

b. Flood damages.

(1) General. Flooding along the Wabash River occurs almost every year and often several times a year. Major floods usually occur during the winter and early spring months with principal damages resulting to urban areas, transportation routes and non-crop agricultural properties. These major floods remain above flood stage for extended periods and cause great tangible damage, long delays in transportation movements, and almost complete disruption of all economic activity. It is of particular significance that many agricultural levees are overtopped or breached during major flooding at a time when repairs prior to the growing season are virtually impossible. Medium and low stage floods have happened during every month of the year but are of particular importance when occurrences have been in the late spring or early summer months. Flooding during this period delays planting, necessitates costly replanting and sometimes prevents the use of arable lands for an entire cropping season. In the lower portion of the Wabash River where the overflow area is largely unprotected, major tributaries contribute considerable inflow, which when combined with Ohio River backwater often maintains stages above bankfull for periods up to 50 days. Soil conditions after such flooding are such that preparation and planting cannot be accomplished during that crop season.

(2) Tangible damages of specific floods - Wabash Basin. Estimates of damages have been reported for various historical floods in the Wabash River basin, including the maximum record flood of March 1913. The reliability and over-all coverage of these estimates are unknown. However, it is considered that reported damages are somewhat indicative of damages under conditions and values current at the time of the flood. A tabulation of some of the most damaging of these recorded historical floods is given below.

Flood	Estimated Damage
1913 - flood of record	$ 25,000,000
1919	6,000,000
1927	6,000,000
1930	5,947,000
1938	2,425,000

The May 1943 flood, the second highest flood of record in a large portion of the Wabash River basin was the first major flood for which a flood damage survey was initiated by the U. S. Army Engineer District, Louisville, Kentucky, and for which damage data are available. The survey for this flood included essentially all of the inundated area and considered all types of damages to properties affected. It was estimated at the time that damages resulting

from the May 1943 flood were $23,017,000. From 1943 to mid-1962, there have been 12 floods of consequence in the Wabash River basin. Not all of these floods were basin wide but each had considerable impact along the main stem of the Wabash River. The most damaging of these floods was the June-July 1958 flood which, because of the time of occurrence, resulted in great agricultural losses along the Wabash River and its major tributaries. Losses sustained from this flood were estimated to be $26,241,000 of which $14,267,000 were along the Wabash River main stem. Other recent floods which caused great damages were: 1947 - $13,970,000; 1957 - $12,837,000; and 1961 - $14,037,000.

(3) Tangible damages - Wabash River and tributaries. To define the flood problem in the areas studied for this report, an analysis was made of recent flood damage survey data and economic studies of the subject areas. Field surveys were made to obtain new data and to modify and adjust previously compiled data to represent current conditions of development and flood damages. Considered in the evaluation of damages were physical damage to buildings and contents, lands, fences, transportation routes, and levees. Crop losses were measured as either the additional expenditures to produce the crop or the non-recoverable portion of the value less the non-incurred expenditures. Business losses, lost wages, emergency expenses, and traffic re-routing costs and delays were also included. Table 5 presents a summary of the losses that could be expected to result from recurrence in 1963 of the record March 1913 flood and the June 1960 flood, a recent cropping season flood. Generally, the March 1913 flood is the maximum of record in the Wabash River Basin and has been selected for presentation of data for this and other reports. However, at several gaging stations along the Patoka River, this flood has been exceeded by several more recent flood occurrences. Additional data on flood damages are presented in Appendix B.

TABLE 5

ESTIMATED DAMAGE FOR RECURRENCE OF SPECIFIC FLOODS

Stream and reach	Mile to mile	Damages for flood recurrence(1) June 1960 ($1,000)	Damages for flood recurrence(1) March 1913 ($1,000)
Wabash River			
W-1	0.0 - 40.0	1,673	1,396
W-2	40.0 - 94.5	1,662 (2)	3,756 (2)
W-3	94.5 - 124.2	321	1,730
Total Wabash River		3,656	6,882
Embarrass River			
EM-1	0.0 - 63.8	810	1,015
EM-2	63.8 - 103.2	475	329
Total Embarrass River		1,285	1,344
White River			
WH-1	0.0 - 51.6	925	442
East Fork White River			
EW-1	51.6 - 111.9	904	666
EW-2	111.9 - 146.2	256	187
EW-3	146.2 - 183.7	602	287
EW-4	183.7 - 238.3	2,164	1,971
Total East Fork White River		3,926	3,111
Clifty Creek			
CC-1	0.0 - 18.4	11	451
Total White and East Fork White Rivers and Clifty Creek		4,862	4,004
Patoka River			
P-1	0.0 - 17.5	217	45
P-2	17.5 - 34.6	177	338
P-3	34.6 - 54.8	179	80
P-4	54.8 - 62.2	10	32
P-5	62.2 - 81.1	109	137
P-6	81.1 - 106.0	110	593
P-7	106.0 - 118.3	37	43
Total Patoka River		839	1,268

(1) 1963 values and conditions
(2) Mt. Carmel, Ill., excluded (local protection anticipated in near future)

(4) Tangible damages - Ohio River. The greatest flood of record along the Ohio River below the Wabash River was that of January 1937. Estimated damages at the time of flood occurrence for this lower portion of the river were $18 million. Recent studies of this area indicate that recurrence of the January 1937 flood with present conditions and price levels would also result in damages of about $18 million. However, flood protection is now provided by Federally constructed projects at the damage centers of Paducah, Kentucky, and Rosiclare, Golconda, Mounds and Mound City, Illinois. These areas were not protected in 1937 and sustained a large part of the damages at that time.

(5) Average annual damages. Average annual damages for all areas were developed by use of the damage frequency method of developing annual flood losses. Using this method, annual losses are derived by combining data from stage-damage curves and comparable stage-frequency curves. Initially, natural frequency curves were modified to reflect the operation of existing reservoirs and those to be completed in the near future. A summary of average annual damages by stream reaches is given in table 6. Additional data on flood damages and damage curves are given in Appendix B. Flood frequency data and frequency curves are presented as a part of Appendix D, Hydrology and Hydraulics.

TABLE 6

ESTIMATED AVERAGE ANNUAL DAMAGES BY STREAM REACHES

Stream and reach	Mile to mile	Average annual damage (1) ($1,000)
Wabash River		
W-1	0.0 - 40.0	676
W-2	40.0 - 94.5	583
W-3	94.5 - 124.2	496
Total Wabash River		1,755
Embarrass River		
EM-1	0.0 - 63.8	938
EM-2	63.8 - 103.2	358
Total Embarrass River		1,296
White River		
WH-1	0.0 - 51.6	315
East Fork White River		
EW-1	51.6 - 111.9	206
EW-2	111.9 - 146.2	66
EW-3	146.2 - 183.7	455
EW-4	183.7 - 238.3	1,715
Total East Fork White River		2,442
Clifty Creek		
CC-1	0.0 - 18.4	37
Patoka River		
P-1	0.0 - 17.5	158
P-2	17.5 - 34.6	479
P-3	34.6 - 54.8	371
P-4	54.8 - 62.2	57
P-5	62.2 - 81.1	255
P-6	81.1 - 106.0	233
P-7	106.0 - 118.3	45
Total Patoka River		1,598
Total Wabash River and tributaries		7,443
Ohio River		
O-1	981.0 - 920.4	159
O-2	920.4 - 848.0	695
Total Ohio River		854

(1) 1963 values: Damages are residual to reservoir and levee projects existing, under construction, or in advanced planning stage.

(6) Intangible damages. Intangible damages caused by flooding, although not monetarily evaluable, are of considerable importance in the area studied for this report. Flooding in urban areas results in evacuation of many persons and subsequent crowding of a large number of persons into emergency quarters, which in general, lack necessary sanitary facilities and adequate food preparation and distribution equipment. Family units become disrupted and increased anxiety results for separated members. In rural areas many dwellings are located on ridges, knolls and piers, which become isolated during medium and high stage floods. During periods of inundation, roads become impassible, disrupting transportation and other normal means of communication and causing delays of emergency assistance in the event of fire, illness or other calamity. Depths and velocities of water increase hazards to life. Major flooding in the study area usually occurs in winter months and is generally of long duration. Exposure and hazards to life by flooding at any time disrupts normal economic and social activities of the surrounding area in addition to the inundated area.

16. RECREATION NEEDS.

Each of the three proposed reservoirs, Lincoln, Clifty Creek and Patoka, is located in an area lacking in water associated recreational facilities. Several metropolitan areas are found in the vicinity of each reservoir, from which large annual reservoir visitations may be expected. From studies and estimates made by the Bureau of Outdoor Recreation and the Fish and Wildlife Service, it is concluded that there is a great need for both general and fish and wildlife recreation in each of the proposed reservoir areas. Reports of these agencies are summarized in Section X of this report.

17. WATER SUPPLY AND WATER QUALITY CONTROL NEEDS.

The U. S. Public Health Service has made studies concerning water supply and water quality control at each of the proposed sites. Conclusions for Lincoln Reservoir indicate that there is a present need for low flow augmentation on the Embarrass River in the interest of water quality control, and that Charleston, Illinois, will require additional water supply in the future. For the area around and below Clifty Creek Reservoir, there is no present need for water supply or water quality control, but future needs are forecast. Both the U. S. Public Health Service and the Indiana Flood Control Commission indicate there is a definite need for water supply and low flow augmentation downstream from the proposed Patoka Reservoir. The report of the U. S. Public Health Service is summarized in Section X of this report.

18. IRRIGATION.

The Soil Conservation Service of the U. S. Department of Agriculture has made a preliminary examination of needs for irrigation of areas in the vicinity of the reservoirs considered in this report which

could be served by the reservoirs. No needs are forecast below the Lincoln and Patoka projects. However, the practice of irrigation is growing along Clifty Creek, and the East Fork of White River below Clifty Creek Reservoir site and above the Bartholomew-Jackson County line. Future water supply for this purpose is therefore indicated.

19. EXISTING CORPS OF ENGINEERS' PROJECTS IN WABASH RIVER BASIN.

a. Projects, completed, under construction, partially completed or under advance planning.

(1) Reservoirs. Six flood control reservoirs in the Wabash basin fall in this category. Mansfield Reservoir located on Raccoon Creek, a tributary of the Wabash River, and Cagles Mill Reservoir located on Mill Creek, in the White River Basin, are the only reservoirs completed. Construction of Monroe Reservoir was started in November 1960 and is expected to be completed in fiscal year 1965. Mississinewa, Salamonie and Huntington Reservoirs were started in fiscal years 1962 and 1963 and all three are expected to be completed by fiscal year 1968. Pertinent data on these reservoir projects are given in table 7 and their locations are shown on plate 1.

(2) Local protection projects. Seventeen local flood protection projects are in this class. Seven projects are complete, three are partially complete, two are under construction. On two projects pre-construction planning is completed, one of which is awaiting acquisition of rights-of-way and one assurance of local cooperation. The remaining three projects are in the advance planning stage. Pertinent data for these projects are given in table 7, and their locations are shown on plate 1.

b. Projects authorized but not started. In addition to the projects mentioned in the previous paragraph, construction of local flood protection projects are authorized at 33 other localities in the Wabash River Basin. Twenty-five of these projects are for the protection of rural areas, seven are for the protection of urban areas and one project is for both rural and urban protection. These projects are listed in table 8 and their locations shown on plate 1. This effect upon these projects is recognized in the benefit analysis contained herein. Studies of these local protection projects and recommendations for their disposition will be made, along with all other local protection projects, in the final Wabash River Basin Comprehensive Report. No project for flood control or allied purposes for which the Corps of Engineers is responsible, has been funded by Congress for construction within the Embarrass River, Clifty Creek or Patoka River basins.

TABLE 7

CORPS OF ENGINEERS' FLOOD CONTROL PROJECTS COMPLETED, UNDER CONSTRUCTION OR IN ADVANCED PLANNING IN WABASH RIVER BASIN

RESERVOIRS

Item	Name of reservoir: Mansfield	Mississineva	Salamonie	Huntington	Cagles Mill	Monroe
Status of completion	Completed in 1961	Started in April 1962	Started Dec 1961	Started in spring of 1963	Completed in June 1953	Started in Nov 1960
Pertinent data:						
Miles above mouth	32.4 mi.	7.1 mi.	3.1 mi.	411.4 mi.	2.8 mi.	25.65 mi.
Location, stream	Raccoon Creek	Mississineva River	Salamonie River	Wabash River	Mill Creek	Salt Creek
Drainage area, sq. mi.	208	809	557	707	295	441
Reservoir storage						
Min. pool, A.F.	16,200	23,300	13,100	4,100	27,100	182,200
Seasonal pool, A.F.	33,100	75,200	60,700	8,400		
Flood control, winter, A.F.	116,600	345,100	250,500	149,000	201,010	258,800
Total, A.F.	132,800	368,400	263,600	153,100	228,100	441,000
Total, r/o in inches	12.0	8.5	8.9	3.9	12.8	18.8
Reservoir pool area						
Min. pool, acres	1,100	1,280	976	500	1,400	10,750
Seasonal pool, acres	2,060	3,180	2,855	900		
Flood control, acres	3,900	12,830	9,340	7,900	3,440	7,700

TABLE 7 (Cont'd)

CORPS OF ENGINEERS' FLOOD CONTROL PROJECTS COMPLETED, UNDER CONSTRUCTION OR IN ADVANCED PLANNING IN WABASH RIVER BASIN

RESERVOIRS

Item	Name of reservoir					
	Mansfield	Mississinewa	Salamonie	Huntington	Cagles Mill	Monroe
Total project cost (2) (in $1,000)	$6,219	$28,181(1)	$18,889	(1) $20,707(1)	$4,183.8	$13,890
Date of Estimate	(1962)	(1963)	(1963)	(1963)	(1963)	(1963)

(1) INCLUDES FEDERAL AND NON-FEDERAL COSTS
(2) CURRENT APPROVED ESTIMATE (1963)

TABLE 7 (Cont'd)

LOCAL PROTECTION PROJECTS

Name	Location	Area protected (acres)	Status (end of F.Y. 63)	Total (1) project cost (est.date)
COMPLETED PROJECTS				
New Harmony Bridge Bank Protection, Wabash River Ill. & Ind.	New Harmony, Indiana and White Co., Ill.	Highway Bridge	Completed in Feb 1958	$751,000 (1963)
Levee Unit 8 White River Indiana	Left bank in Daviess Co.	13,400 rural	Completed in Nov. 1949	$850,534 (Est.Actual)
Gill Township Levee; Wabash River, Ind.	Left bank in Sullivan Co.	12,000 rural	Completed in 1947	$579,200 (Est.Actual)
Lyford Levee Wabash River Indiana	Left bank in Parke County	3,500 rural	Completed in Nov. 1943	$286,900 (Est.Actual)
Delphi, Ind. Levee; Wabash R.	Left bank in Carroll Co.	City of Delphi Urban	Completed in Aug. 1951	$154,600 (1963)
Muncie, Ind. White River, Indiana	Both banks in Delaware Co.	City of Muncie, Ind. Urban	Completed May 1950	$990,835 (Est.Actual)
Portland, Ind. Channel Improvement Salamonie R.	Joy Co., Ind. at and downstream of Portland, Ind.	City of Portland	Completed Aug. 1961	$ 97,150(2)
PARTIALLY COMPLETED PROJECTS				
Brevoort Levee Wabash & White Rivers, Ind.	Left bank Wabash R. Right bank White R. Knox Co., Ind.	50,000 rural	Project 67% completed in Sep. 1947	$2,520,000 (1963)
Indianapolis, Ind., Fall Cr. and Warfleigh Sections; White R.	Both banks in Marion County	urban	Partial project completed 1950	$11,600,000 (1960)

TABLE 7 (Cont'd)

Name	Location	Area protected (acres)	Status (end of F.Y. 63)	Total project cost (est.date)
Vincennes, Ind. Wabash R., Ind.	Left bank in City of Vincennes, Knox County	Vincennes, Ind. urban	65% of project completed at end of F.Y. '63	$5,205,000 (1963)
PROJECTS UNDER CONSTRUCTION				
Levee Unit 5 Wabash, Patoka and Black R., Indiana	Left bank of the Wabash R. in Gibson and Posey Counties	44,000 rural and towns of Lyles, Shelton & Griffin	First contract awarded, Const. not started	$9,213,000 (1963)
Mason J. Niblack Levee, Wabash R., Ind.	Left bank in Sullivan and Knox Counties	15,620 rural	Section I completed Apr 1963 Section II 15% complete	$1,990,000 (1963)
PROJECTS UNDER ADVANCE PLANNING				
Rochester and McClearys Bluff Levee; Wabash R., Illinois	Right bank in Wabash Co., Ill.	5,060 rural	General design memorandum 75% complete	$1,322,000 (1963)
Mt. Carmel Levee, Wabash R., Illinois	Right bank in Wabash County	380 rural 160 industrial and semi-urban	General design memorandum 75% complete	$1,613,000 (1963)
Tri-Pond Levee Wabash R., Ill.	Right bank in Crawford Co.	4,960 rural	General design memorandum 75% complete	$1,357,000 (1963)
Terre Haute Indiana; Wabash R.	Left bank in Vigo County	110 urban	Advanced plng. completed awaiting assurance of local cooperation	$ 9,000 (1960)
West Terre Haute, Wabash R.	Right bank in Vigo County	410 urban	Advanced plng. completed awaiting furnishing of necessary rights-of-way	$ 825,000 (1963)

(1) Includes Federal and non-Federal costs.
(2) Actual Federal cost only.

TABLE 8

FEDERAL FLOCD PROJECTS AUTHORIZED BUT NOT STARTED IN WABASH RIVER BASIN - (APPROXIMATE LISTING ACCORDING TO RIVER MILE DISTANCE OF PROJECT ABOVE MOUTH OF WABASH RIVER)

Name	Location	Area protected (acres)	Year of authorizing act	Estimated cost of protection (latest)
Levee Unit 1 Wabash River Illinois	Right bank in Gallatin Co.	23,400 rural	1936	$ 4,526,000 (1960)
Levee Unit 2 Wabash River Indiana	Left bank in Posey Co.	25,400 rural	1936	4,088,000 (1960)
Levee Unit 3 and 4, Wabash River, Illinois	Right bank in White County	49,600 rural	1936	9,635,000 (1963)
New Harmony Wabash River Indiana	Left bank New Harmony	Urban protection	1946	641,000 (1954)
Bonpas Creek Illinois	Channel improvement, Edwards Co	rural	1946	1,012,000 (1963)
Levee Unit 1 Little Wabash R. Illinois	Right bank in Wayne, White and Edwards Counties	18,000 rural	1946	3,014,000 (1961)
Levee Unit 2 Little Wabash R. Illinois	Left bank in Wayne County	7,360 rural	1946	2,028,000 (1963)
Levee Unit 17 White and Patoka Rs. Indiana	Left bank White River Gibson County	rural	1946	961,000 (1963)
Levee Unit 1 White River Indiana	Left bank White River Pike Co.	rural	1946	2,296,000 (1961)
England Pond Wabash R and Embarass R Illinois	Right bank in Lawrence County	6,370 rural	1946	812,000 (1963)

TABLE 8
(Cont'd)

Name	Location	Area protected (acres)	Year of authorizing act	Estimated cost of protection (latest)
Russell and Allison Levees, Wabash R., Ill.	Right bank in Lawrence Co.	33,000 rural	1938	$ 7,365,000 (1960)
Levee Unit 7 White River Indiana	Right bank in Knox County	rural	1946	1,578,000 (1961)
Shufflebarger Levee, White River Indiana	Left bank in Greene and Davies Cos.	urban protection	1946	2,470,000 (1958)
McGinnis White River Indiana	Left bank White River, Greene and Knox Cos.	rural	1946	1,924,000 (1954)
Shoals, Ind. Levee	Martin Co. East Fork, White River	urban protection	1936	572,000 (1954)
Orleans, Indiana (Channel excavation from sink holes)	Orange Co. Lost River White River Basin	urban protection	1950	612,000 (1957)
Island Levee, Wabash River, Indiana	Left bank in Sullivan Co.	5,300 rural	1946	2,019,000 (1965)
Levee Unit 6 Wabash River, Illinois	Right bank in Clark County	6,700 rural	1938	1,216,000 (1954)
Greenfield Bayou Levee, Wabash River Indiana (1)	Left bank in Vigo County	11,400 rural	1946	2,442,000 (1960)
Levee Unit 1, Eel River, Ind. White River Basin	Right bank in Clay & Greene Counties	rural	1946	491,000 (1960)

(1) Feasibility study in process.

TABLE 8
(Cont'd)

Name	Location	Area protected (acres)	Year of authorizing act	Estimated cost of protection (latest)
Levee Unit 2 Eel River, Indiana White R. Basin	Left bank in Clay Co. along Connelly Ditch	rural	1946	$ 2,805,000 (1954)
Levee Unit 2 East Fork, White R., Ind.	Right bank in Jackson Co.	rural	1946	797,000 (1961)
Levee Unit 3 E. Fork, White R., Indiana	Right bank in Jackson and Bartholomew	rural	1946	3,838,000 (1961)
Honey Creek Levee, Wabash R., Indiana	Left bank in Vigo County	1,520 rural	1938	685,000 (1954)
Sugar Creek Levee, Wabash River Indiana	Right bank in Vigo County	1,500 rural	1938	447,000 (1960)
Levee Unit 9 White R., Ind.	Right bank in Greene Co.	rural	1936	30,000 (1957)
Levee Unit 10 White and Eel Rivers, Ind.	Right bank in Greene Co.	urban rural	1936	201,000 (1957)
Clinton, Indiana Wabash River	Right bank in Vermillion Co.	urban	1938	86,000 (1954)
Raccoon Levee Wabash River Indiana	Left bank in Parke Co.	1,000 rural	1946	463,000 (1960)
Adams Levee Wabash R., Ind.	Left bank in Parke Co.	1,260 rural	1938	306,000 (1960)
Fletcher and Sunshine Gardens Levee White R., Indiana	Left bank in Marion Co.	urban	1946	574,000 (1960)

TABLE 8
(Cont'd)

Name	Location	Area protected (acres)	Year of authorizing act	Estimated cost of protection (latest)
Anderson, Ind. White River	Right bank in Madison Co.	City of Anderson	1936	$ 578,000 (1954)
Deer Creek Prairie Levee Wabash River, Indiana	Right bank in Carroll and Tippecanoe Counties	1,730 rural	1938	223,000 (1960)

20. IMPROVEMENTS BY OTHER FEDERAL AND NON-FEDERAL AGENCIES

a. Projects by other Federal Agencies. The Watershed Protection and Flood Prevention program (authorized by Federal Public Law 566) in the Wabash River basin includes a total of 56 projects. This program is administered by the Soil Conservation Service, U. S. Department of Agriculture. At the end of fiscal year 1963, there were 11 projects in the Wabash River basin; one of which is completed, five are under construction, and five are authorized but not started. In addition, 45 potential projects have been identified, but not authorized. The only S.C.S. project under construction in the reservoir basins considered in this report is the Scattering Fork project in the Embarrass Basin. There will be no significant conflict between this project and the Lincoln Reservoir project.

b. Improvements by non-Federal Agencies.

(1) Flood control. Numerous levees and channel improvements offering varying degrees of flood protection have been constructed by non-Federal interests in the Wabash River Basin. A description of these projects is included in H. D. No. 197, 80th Congress, 1st Session. Non-Federal flood control improvements since the preparation date of H. D. 197 (1944) are of minor significance. These improvements consist of low-height temporary diking constructed on private lands by private interests mainly for crop protection from frequent low-stage floods occurring during the crop growing season. There are no non-Federal flood control projects in the Clifty Creek Basin. In the Embarrass River Basin, there are eight locally constructed projects, all below the proposed reservoir site. In the Patoka River Basin, there is only one significant local flood control project below the reservoir site. The existence of these levees is recognized in the benefit analyses contained herein.

(2) Recreation areas. There are two state parks in the immediate vicinity of the Lincoln Reservoir site, Embarrass River. They are Lincoln Log Cabin State Park and Fox Ridge State Park, emcompassing 86 acres and 783 acres of wooded land, respectively. Both parks have picnicking and camping facilities. The locations of these parks are shown on plate 2. There are no state park facilities in the vicinity of Clifty Creek or Patoka Reservoirs.

21. IMPROVEMENTS DESIRED.

a. Records of public hearings. Records of public hearings held in connection with the projects presented in this report are summarized in the following paragraphs.

b. Lincoln Reservoir. On 25 January 1962 a public hearing was held in Greenup, Illinois, for the purpose of securing the views and desires of local interests concerning measures which should be adopted for flood control and allied purposes on the Embarrass River and tributaries, Illinois. This hearing indicated support for a comprehensive

study of the basin and formulation of a comprehensive plan for development of its water and land resources. Studies of the basin were accordingly continued and Lincoln Reservoir, as proposed in this report, would be an initial element of a comprehensive plan of development.

On 10 December 1963 a public hearing was held in Charleston, Illinois, to inform all concerned of the purposes, physical features and general economic aspects of Lincoln Reservoir and to obtain information which would be helpful in the formulation of final plans and recommendations for this project for this report. Approximately 2,000 persons attended including Federal, State, county and city officials and citizens of rural and urban areas. Testimony of Government officials and Members of Congress was uniformly in favor of the project on the basis of its potential accomplishments for flood control, water quality control, water supply, and recreation; and as a general stimulant to the local economy. The majority of individuals and local organizations were likewise in favor of the project. Opponents were generally landowners in the reservoir area, landowners adjacent to the reservoir in its upper reaches who feared impaired drainage of their lands, and persons concerned about removal of reservoir lands from tax rolls. The preponderance of opinion was in favor of the project as proposed herein.

c. Clifty Creek. On 18 September 1962 a public hearing was held at Bedford, Indiana, to secure views and desires of local interests with respect to possible improvements of the East Fork of the White River and its tributaries, in Indiana, in the interest of flood control and water resource development. Clifty Creek reservoir would be in the area considered but no project was presented at the hearing and no specific comments were received relating to improvement of Clifty Creek. Formulation of the Clifty Creek Reservoir proposal followed this hearing.

On 11 December 1963 a public hearing was held in Columbus, Indiana, to inform all concerned of the purposes, physical features and general economic aspects of Clifty Creek Reservoir as presented herein, and to obtain information which would be helpful in the formulation of final plans and recommendations for this project for this report. Approximately 500 persons attended including Federal, State, county and city officials and citizens of rural and urban areas in the vicinity. Testimony was predominantly in favor of the project with principal objectors being landowners who would be displaced by the reservoir. Representatives of the City of Columbus and the State of Indiana pointed out the possible future need for utilization of storage space in the reservoir for water quality control and water supply. The project as presented, due to limited storage capability, was based on flood control storage only, and recreation benefits associated therewith.

d. Patoka. On 28 August 1962 a public hearing was held in Jasper, Indiana, for the purpose of securing the views and desires of local interests concerning measures which could be adopted for flood control and allied purposes on the Patoka River and tributaries in southwestern Indiana. At this time Patoka Reservoir site was under study. Testimony at the hearing included proponents and opponents to a major reservoir at this location. Nature of interest displayed was such that study of the project was continued.

On 12 December 1963 a public hearing was held at Jasper, Indiana, to inform all concerned of the purposes, physical features, and general economic aspects of Patoka Reservoir, and to obtain information which would be helpful in formulation of final plans and recommendations for this project for this report. Approximately 900 persons attended including Federal, State, county and city officials and citizens of rural and urban areas in the vicinity. Testimony of Members of Congress, Government officials, and representatives of a majority of individuals was in support of the project in recognition of its potential flood control, conservation, and recreation accomplishments. Principal opponents were landowners in the potential reservoir area. The preponderance of opinion was in favor of the project.

SECTION V - SUMMARY OF WATER RESOURCES PROBLEMS AND SOLUTIONS CONSIDERED

22. FLOOD PROBLEMS.

Flood flows arising in the upper basins of Embarrass River, Clifty Creek and Patoka River contribute to flood damages in downstream flood plains. Large areas of agricultural lands in the flood plains are subject to frequent flooding resulting in damages to crops, soil, livestock and other damages common to rural areas. A number of urban and semiurban areas in the flood plains have inadequate or no flood protection. Many business, industrial and small manufacturing concerns, public buildings, residences and other improvements are located in these high damage areas. Extensive railroad, highway and utility systems experience flood damage. Flood damages are reduced to some extent by the operation of completed projects and the projects now under construction will further alleviate flooding. Despite these improvements, recurrence of major floods will continue to cause vast and widespread damages in the Wabash Basin.

23. WATER SUPPLY AND WATER QUALITY CONTROL.

Water supply and water quality control needs in the vicinities of the projects considered in this report have been studied by the U. S. Public Health Service, a cooperating agency for the Wabash River Basin Comprehensive Study. Their reports, included in Appendix F, Exhibit F-6, consider needs for an early future date, and needs for the year 2010. Preliminary estimates of minimum flow requirements to meet these needs are expressed therein in ranges of flow applicable to given points. Considering these specified flows and other factors such as site storage capabilities, expressions of local interests with regard to reimbursable storage allocations, and uncertainty of future estimates, provisions for storage for water quality control and water supply have been made for projects in this report as follows:

a. Lincoln Reservoir. Public Health Service studies indicate a need for downstream low flow augmentation in the interest of water quality control and future water supply. A storage allocation of 5,300 acre-feet, capable of sustaining a minimum withdrawal of 25 cubic feet per second from the reservoir is included in the reservoir plan to meet downstream low flow augmentation requirements and to provide 10 cubic feet per second water supply need for the City of Charleston, Illinois. The City of Charleston has indicated its willingness to reimburse the Government for future water supply costs. With the large minimum pool necessary for this project, additional future needs can be met by minor adjustment of the initial minimum or conservation pool levels.

b. Clifty Creek Reservoir. No present water supply or water quality needs are evident. However, there is an estimated future need for maintenance of minimum flow of 20 cubic feet per second in Clifty Creek. Such need is based on future construction of a sewage disposal plant on Clifty Creek and dilution volume necessary to provide adequate water quality for water supply needs on the East Fork

White River. Due to limited storage capability, the present project plan does not include conservation storage but future allocation of storage thereto may be practicable depending on future value of storage or future development of additional flood control storage in the vicinity to replace storage at Clifty Creek Reservoir.

c. Patoka Reservoir. The maximum practicable conservation pool for Patoka Reservoir would be from the minimum pool at El. 506 to El. 536 and would provide a storage of 167,500 acre-feet for downstream low flow augmentation in the interest of water supply and water quality control. This storage is sufficient to sustain a continuous withdrawal of 198 cubic feet per second from the reservoir. The U. S. Public Health Service estimates that a minimum flow of 68 cubic feet per second will be required for water quality control and that an additional 8.4 cubic feet per second will be required at Jasper by the year 2010. The Public Health Service has also indicated that additional studies may verify a need for a minimum flow of 125 to 200 cubic feet per second at Princeton to provide an acceptable raw water supply for Princeton.

The State of Indiana has requested that conservation storage in Patoka Reservoir be developed to the maximum practicable limit and has expressed the desire to acquire rights to the available water supply storage in accordance with the 1958 Water Supply Act as amended.

To meet Public Health Service's requirements for water quality control, storage sufficient to sustain a minimum reservoir release of 68 cubic feet per second has been allocated to water quality control. The remainder of the conservation pool storage, capable of providing an additional 130 cubic feet per second minimum release concurrent with water quality control releases, will be purchased by the State of Indiana.

24. GENERAL RECREATION.

The Bureau of Outdoor Recreation has studied the recreation potential associated with the three reservoirs presented herein. Their reports, included in Appendix F, analyze present recreation demands and projects demands to the year 2000. For each area an important present demand for water-associated recreation opportunities exists, and a greatly increased future demand, commensurate with future population growth, is foreseen. To best satisfy these potential demands the maximum practicable pool size is desirable during the summer months. Accordingly, based on engineering analyses, the minimum pool level would be maintained to the extent possible during the period 1 December to 1 April when floods are most frequent and of greatest volume, and a somewhat higher seasonal pool would be planned for the recreation season, 1 May to about 1 September, when the flood risk is less. The seasonal pools proposed herein for Lincoln and Clifty Creek reservoirs will be completely filled about 3 years out of four and hence provide good recreation opportunities. The conservation pool proposed for Patoka Reservoir would be maintained, on the average, for 90 percent of the time during the recreation season.

25. FISH AND WILDLIFE RECREATION.

Information on the needs for development of the fish and wildlife recreation opportunities of the potential reservoirs considered in this report are included in separate reports from the U. S. Fish and Wildlife Service which are contained in Appendix F. In each case the projects would improve the local fishery by provision of a large lake, and by provision of a fish attraction area in the vicinity of the reservoir outlet works stilling basin. In each case, also, existing farm game wildlife habitat will be affected. In the cases of Lincoln and Clifty Creek reservoirs these effects would not be significant. In the case of Patoka reservoir some damage to the upland game resource may occur, but will be largely offset by increased waterfowl hunting. Costs for mitigation of the overall loss incurred, as discussed in Section X, are considered to be excessive and mitigation measures are not proposed.

26. IRRIGATION.

The Soil Conservation Service of the Department of Agriculture in their preliminary reports contained in Appendix F foresees no irrigation needs below the projects herein with the exception of Clifty Creek Reservoir. Inasmuch as the storage capability of this site is limited, no present storage allocation for this purpose is proposed. This will not preclude future allocation of storage for this purpose dependent on the following factors: (a) development of definite demand and repayment ability, (b) value of storage as compared to flood control, water supply, and water quality control use, and (c) development of additional flood control storage in the project vicinity.

27. HYDRO-ELECTRIC POWER.

With a rapidly increasing demand for power, hydroelectric power generation at the projects considered in this report would be desirable. Possibilities in this regard have been examined by the Federal Power Commission and their reports thereon are contained in Appendix F. Conclusions of those reports are that power installations at the projects would not be economically feasible. It is pointed out, however, that these conclusions should be reviewed in more detail if construction of any of the projects is undertaken.

28. RESERVOIR SITES CONSIDERED.

a. Lincoln Reservoir. Since about 1930, reservoir development on the Embarrass River has been considered in connection with the "308 Report", H. D. No. 197, 80th Congress, and detailed studies for the Wolf Creek Reservoir project which was authorized by the Flood Control Act of 1938 and deauthorized by the Flood Control Act of 1946. A review of these studies, along with consideration of changes in conditions which have occurred during the intervening period, resulted in the selection of a reservoir with a dam site 103 miles above the mouth of the stream.

This site is considered as having the greatest merit from the standpoint of physical storage capability, large area benefited and low costs of development.

b. Clifty Creek Reservoir. This reservoir would control 140 square miles of the 200-square mile drainage area of Clifty Creek. It is considered to be the best potential reservoir site in the East Fork White River Basin, where needs for water resource development are great and storage potentials are restricted by cavernous limestone foundations in some areas, and lack of stream entrenchment in others.

c. Patoka Reservoir. This site is supported by the Indiana Flood Control and Water Resources Commission as a major element for control of Patoka River. Although located near the head of the Patoka River Basin, which is long and narrow, and thus not affording optimum drainage area control, the flood plain is so wide downstream, and tributaries so short and steep, that development of equivalent storage at alternate locations would be more costly than the plan presented herein.

d. General Considerations. The projects selected for presentation in this interim report are those for which adequate data are available, in advance of completion of the Wabash River Basin Comprehensive Study, to support recommendations for project authorization and to assure compatability with any comprehensive plan for basin development. As shown in table 14 of this report, all projects and all purposes recommended are economically justified by wide margins. As to compatability with the optimum comprehensive plan, Lincoln and Patoka Reservoir sites are the most efficient storage sites in the Embarrass and Patoka River Basins, are primarily justified by benefits within these basins, and are thus necessary elements of any comprehensive plan. In the case of Clifty Creek, the proposed reservoir will only provide for a small part of indicated flood control and conservation storage needs and will not preclude development of any other potentials in the area. It, therefore, is also a desirable element of any comprehensive basin plan.

SECTION VI - RESERVOIR PLANS

29. DEVELOPMENT OF RESERVOIR PLANS.

a. General. Studies made for this report were limited to the development of reservoir projects in the Embarrass River, Clifty Creek and Patoka River basins. These reservoirs are: Lincoln Reservoir on Embarrass River, Clifty Creek Reservoir on Clifty Creek and Patoka Reservoir on Patoka River. The locations of these reservoirs are shown on plate 1. Area and capacity curves, reservoir maps, and plans and sections of structures for the reservoir projects are shown on plates 2 through 7.

b. Development of projects. The development of reservoir projects reported herein follows, within practical limits, the objectives of (1) selection of projects which would best meet the present and near future

needs of the basin, (2) selection of the most economical projects to fill the basin needs, and (3) selection of projects having an optimum level of development as indicated by the greatest excess of benefits over costs. In connection with the latter criterion, however, control of the maximum flood of record, where possible, is considered to be an objective warranting detailed consideration in view of the urban development and future growth anticipated downstream from the reservoir. Likewise, in view of the limited potential for reservoir storage in the Wabash River Basin, maximum storage development consistent with physical capability of reservoir sites and water supply controlled, is a desirable objective. This latter consideration is generally compatible with desires of States concerned and with the objectives of comprehensive planning for the Wabash Basin. Additional information on formulation of individual projects for this report is contained in Section VII.

30. DESCRIPTION OF PROJECTS.

a. Lincoln Reservoir.

(1) General. The site of the Lincoln Reservoir project is located in Cumberland, Coles and Douglas Counties, Illinois, on the Embarrass River, a tributary of the Wabash River. The dam site is approximately 103 miles above the mouth of the stream and about 0.3 mile south of the Coles-Cumberland County line. The project is proposed for a multiple-purpose development to include flood control, general recreation, fish and wildlife recreation and water supply and water quality control. The dam site is situated in the general reach which was previously studied in the middle 1940's in connection with advanced engineering and design for the Copper Cave project, an alternate to the Wolf Creek project, which was deauthorized by the 1946 Flood Control Act. The Lincoln site was selected because of more favorable geological conditions indicated by more extensive investigations; see Appendix E. Foundation investigations of the project site indicate bedrock consisting of soft friable weathered sandstone, with glacial till deposits above, containing random sand lenses. The dam would be a rolled earth embankment with a crest 30 feet wide, 2,400 feet long at elevation 648, and a maximum height of 110 feet. Seepage control would be provided by a grout curtain into the abutments and across the valley floor, and by embankment filter drains. The spillway would consist of an open cut through the left abutment with a level base at elevation 629, length of 1,900 feet and width of 100 feet. The spillway is designed to discharge 14,450 cubic feet per second. A cut and cover outlet works, located at the toe of the left abutment and founded on silty-clay shale, would include a control tower with three service gates, 4 feet wide by 8 feet high, a 10-foot diameter circular concrete conduit, transitions and stilling basin. Two small multiple-stage outlets with facilities for reoxygenation would be provided for low flow control.

The Embarrass River has a total drainage area of 2,438 square miles of which 915 square miles are above the Lincoln dam site proposed herein. The City of Charleston's present water supply reservoir and raw water intake and pumping stations would be inundated by Lincoln Reservoir. Compensatory storage in Lincoln Reservoir and revision of other facilities is a Federal responsibility. Storage data for Lincoln Reservoir are given in the following tabulation:

Pool	Elevation (ft.M.S.L.)	Capacity (acre-feet)	Capacity inches runoff	Area (acres)	Length of pool main stream (miles)
Minimum	582.4	55,015	1.13	4,050	24
Conservation	582.4-584	6,300	0.13	4,050-4,310	26
Seasonal	584-596	65,450	1.34	4,310-6,760	34
Flood Control	584-629	476,985	9.77	4,310-21,250	58
Total Storage	629	538,300	11.03	21,250	58

A conservation pool of 6,300 acre-feet would be provided for water supply and water quality control. Of this amount 1,000 acre-feet would be for replacement of the project inundated water supply reservoir of the City of Charleston and 5,300 acre-feet for downstream water quality control and future water supply. This storage would satisfy the preliminary objectives of the U. S. Public Health Service and the needs of the City of Charleston for downstream water quality control and water supply, respectively.

The bureau of Outdoor Recreation has indicated (Appendix F, Exhibit F-4) that a total of 5,000 acres of land would be required for present and future general recreation use. It is estimated that about 1,700 acres of multi-purpose project lands would be used primarily for general recreation and that fee acquisition of an additional 3,300 acres would be required to meet general recreation and associated purpose needs. All of the project lands, including those adjacent to the tailwater, would also be available for recreation. The specific areas for the various recreational activities would be designated during post-authorization project planning. Facilities for recreational development would include those pertaining to picnicking, fishing, boating, tent camping, swimming and hunting. Selected areas would be designated for commercial concessionaires. The wildlife management of these lands would be compatible with any other project uses for which acquisition would be accomplished.

The project recreation plan would provide for an annual visitation increasing from 425,000 to 1,100,000 over the project life. The implementation of the fish and wildlife plan, as recommended by the U. S. Fish and Wildlife Service and as contained in this report, would result in an increase of 85,000 angler days and 300 hunter days.

A total area of 38,800 acres of land would be required for the complete project development, including recreation as outlined above. These areas would include those required for construction, operation of the flood control pool and permanent structures. The total estimated cost of the Lincoln Reservoir is $33,000,000. Pertinent data for this project are shown in table 9. A map of the reservoir area and area and capacity curves are shown on plate 2. Plan and sections of the proposed structures are shown on plate 3. A detailed description of the topography and geology of the dam site is given in Appendix E and briefly summarized in the following paragraph.

(2) Foundations. The dam site proposed herein was selected so that most of the permanent pool could be maintained within rock. To reduce leakage through sand lenses in the abutment, the dam should be located near the upstream edge of point or promontory, so that an upstream impervious blanket or fill can be incorporated into the design embankment. Upstream gullies along the abutments would be cleaned and filled to reduce leakage through glacio-fluvial gravel in the till. The abutments are composed of glacial till with lenses of sand and gravel overlying a soft, fine grained, friable, poorly cemented, micaceous sandstone with shaly lamina. Top of sandstone in the abutments varies from elevation 585 to 595. Below the sandstone is a 20 to 25-foot thick silty to clay shale. The shale underlying the sandstone in the abutments is medium hard. In the valley 15 feet of the shale has been stripped off by erosion of the Embarrass River and is overlain by 20 to 25 feet of alluvial fine-grained silty sand. The shale beneath this alluvial sand is very soft and weathered to a depth of 6 to 9 feet below the sand. Preconstruction explorations will be required to determine if this shale should be removed from the cut-off trench area. The friable, poorly cemented sandstone would require tightening by a grout curtain in the abutments and across the valley. The reservoir spillway would have its crest in glacial till. The impervious silty sandy clay excavated from the spillway cut would be used in the dam embankment. Construction materials, with the exception of riprap and coarse aggregate are readily obtainable. Suitable borrow areas are located in the abutments. Cement and fine aggregate could be obtained from commercial sources. Riprap and coarse aggregate sources in the area must be tested.

(3) Lands and damages. Lands required for the project are utilized principally for grain farming. Approximately 145 families reside within the reservoir area, with approximately 20% of the affected farm dwellings either vacant or abandoned. Excellent concrete and asphalt roads traverse the reservoir area in Cumberland and Douglas Counties. The majority of Cole County roads (in the center of the project area) are improved gravel surfaced roads while some near the river are unimproved dirt. Land costs were estimated on the basis of acquisition in fee simple of approximately 35,500 acres of joint-use land, exclusive of for recreation, and improvements thereon. This acreage was determined by taking all lands lying below elevation

634, which includes a five foot freeboard above the proposed spillway crest of 629 feet, or those lands within a 300-foot strip, measured horizontally from the flood control pool, whichever would provide the greater area. A discussion of real estate criteria is contained in paragraph 30.d. Gross appraisal of lands and damages in connection with the construction of Lincoln Reservoir is $12,800,000. A detailed breakdown of the gross appraisal is presented in Appendix A.

(4) Relocations. Relocations or alterations would be necessary for two miles of State highways, one and one-half miles of Federal Aid secondary roads, three miles of single-track railroad and two miles of county roads. There are about six miles each of power and telephone lines that would require some alterations. Two churches, and four cemeteries containing a total of approximately 440 graves, would be moved.

The Charleston water supply reservoir and raw water intake and pumping station would be inundated by Lincoln Reservoir. Compensatory storage in Lincoln Reservoir and revision of other facilities to replace the existing service would be a Federal responsibility. Opportunity would exist for expansion of Charleston water supply storage in the reservoir and local interests have indicated their intention of doing so and assuming costs associated therewith. One pipe line crosses the reservoir near the extreme upper limits of the flood control pool; no alteration is deemed necessary. Slope protection in the form of riprap for the City of Oakland's water supply dam would be required. Relocation and/or alteration would be necessary for experimental fishery facilities located in Fox Ridge State Park; the remaining development in the park would not be disturbed by the reservoir. Summary of relocations required for Lincoln Reservoir is given in the pertinent data table 9. Locations of the existing and proposed road relocations are shown on plate 2.

b. Clifty Creek Reservoir.

(1) General. The site of the Clifty Creek Reservoir project is located in Bartholomew and Decatur Counties, Indiana, on Clifty Creek, a tributary of the East Fork White River. The dam site is 18.4 miles above the mouth of Clifty Creek. The project is proposed for multiple-purpose development to include flood control, general recreation, and fish and wildlife recreation. The Clifty Creek Reservoir site is considered to be one of the better reservoir sites tributary to the East Fork of the White River and the best reservoir site on Clifty Creek.

Clifty Creek dam, with a crest elevation of 753 and a total length of 7,000 feet, would consist of a concrete section in the river 472 feet long, with rolled earth fills of 30-foot top width extending to each abutment. The maximum height of the dam would be 88 feet. The concrete gravity overflow spillway, with crest at elevation 717, would be equipped with three tainter gates 40 feet wide by 28 feet high, with top of gates at elevation 745, which is top of flood control pool for

normal operation. The spillway is designed for a maximum discharge of 71,700 cubic feet per second. Two sluices through the spillway section, 4 feet wide by 6 feet high, with slide gates at the upstream end, would provide for regulated flood releases and low flow control. In the interest of fisheries downstream from the dam, two small multiple-stage low flow outlets with reoxygenating facilities would be provided. Baffles and an end sill would be located on a concrete apron downstream of the spillway ogee section to dissipate the energy of spillway and outlet discharges. Concrete gravity non-overflow sections would flank the spillway and tie into the earth dams which would extend to each abutment. Storage data for Clifty Creek Reservoir are given in the following tabulation:

Pool	Elevation (ft.M.S.L.)	Capacity acre-feet	Capacity inches runoff	Area (Acres)	Length of pool main stream (miles)
Minimum	705	7,655	1.03	548	5
Seasonal	720	18,515	2.48	919	6
Flood Control	705-745	48,553	6.51	2,390	8
Total Storage	745	56,208	7.54	2,390	8

An earth dike 3,500 feet long with a maximum height of 8 feet, a crown width of 12 feet with 1 on 2.5 side slopes, and a top elevation the same as the dam is required across a low point in the valley rim about 4 miles south of the dam. Construction of the proposed Clifty Creek Reservoir would require protection of the town of Hartsville with an earth levee. The levee would be approximately 3,500 feet long and constructed to a top elevation of 753 feet. Necessary drainage facilities would be provided for the area protected. In order to provide for multiple use of the project, it would be necessary to augment flood control land requirements by fee acquisition of 600 acres of land east and south of Hartsville for recreation and recreation-associated purposes, in accordance with Bureau of Outdoor Recreation recommendations (Appendix F, Exhibit F-4). The island located in the Fall Fork pool would be part of the deferred recreational development. All of the project lands, including those adjacent to the tailwater would be available for general recreation, fishing and hunting. The management objectives for these lands would be compatible with the project uses for which they would be acquired. The project plan would accommodate an annual recreation visitation increasing from 200,000 to 800,000 over the life of the project. The implementation of the fish and wildlife plan, as presented in this report, would result in an annual increase of 23,000 angler days. A total land acquisition of 3,880 acres would be required for the complete project development, including recreation as outlined above. The total estimated cost of the Clifty Creek Reservoir is $15,900,000. Pertinent data for the proposed reservoir project is shown in table 9. A map of the reservoir area and area and capacity curves are shown on plate 4. Plan and sections of the proposed structures are shown on plate 5.

(2) Foundations. Foundation investigations indicate that Clifty Creek has cut a 65-foot deep valley into the dolomite and limestone bedrock at Clifty Creek damsite. The alluvial overburden in Clifty Creek channel, however, consists of clay and silty sand averaging about 12 feet in thickness. Glacial till deposits exist above the primary banks and vary in thickness from a few feet to about 80 feet at a buried channel. Two buried channels were encountered during subsurface explorations, one under each abutment. Preconstruction planning explorations will be required to determine the alignment of the buried channels and the imperviousness of the right bank channel cover. The left bank channel is filled with impervious gravelly sandy clay till and no serious leakage problems are anticipated. The dam embankments would be constructed of glacial till. A 30-foot wide cutoff trench to bedrock would be constructed in the valley abutments and across the valley. Grouting would be required the full length of the dam from top of rock to elevation 650. Pervious and impervious borrow can be obtained within the reservoir area and in the Fall Fork Valley. Sands and gravels for drainage, bedding materials and fine aggregates are available from sources near Columbus, Indiana. Quarries which can produce riprap and coarse aggregate are located within 17 miles of the dam site. Testing would be required for these materials and sources. A detailed geology, soils and material report is presented in Section II of Appendix E.

(3) Lands and damages. Lands required for the project are utilized principally for grain farming and livestock operations. Numerous all-weather roads traverse the reservoir and provide adequate access. The high rate of industrial employment in the City of Columbus, Indiana, approximately 12 miles southwest of the dam site has created a market for small acreage homesites immediately west of the reservoir area, and will tend to increase land costs in the area in the future. Gross appraisal for all lands and damages is $1,810,000. Land costs are estimated on the basis of acquisition in fee simple for the purposes listed in Real Estate Criteria, paragraph 30d.

(4) Relocations. There are two cemeteries in the town of Hartsville for which relocation would be required. Hartsville College Cemetery containing 525 graves and a cemetery located in the northwest section of Hartsville, containing 198 graves. Since the reservoir area is not heavily populated, about 60 families would require resettlement. Relocations would also be necessary for approximately 4.3 miles of State highways; 0.85 miles of county roads, and 10 miles each of power and telephone lines.

c. Patoka Reservoir.

(1) General. The site of the Patoka Reservoir project is located in Dubois, Orange and Crawford Counties, Indiana, on Patoka River, a tributary of the Wabash River. The dam site is 118.3 miles above the mouth of the Patoka River. The project is proposed for multiple-purpose development to include flood control, low flow augmentation for water supply and water quality control, general recreation and fish and wildlife recreation. The project proposed herein is the

most desirable and economical for the basin based on preliminary evaluation of costs and benefits applicable to alternates; and degree of control attainable. It is supported by the Indiana Flood Control and Water Resources Commission as a result of their studies. The dam would be a rolled earth and rock fill structure with a crest 30 feet wide, 2,500 feet long at elevation 565, and a maximum height of 89 feet. A transition zone of graded material would be provided between the earth and rock fill. A cutoff trench would be provided in the valley floor. The spillway would consist of a 400-foot wide open cut through the right abutment, having a crest elevation of 550 and a +0.5 percent and -1.5 percent grade for the upstream and downstream slopes, respectively. The base of the spillway would be in unweathered limestone with a few mud seams expected. The material excavated from the spillway cut would be suitable to use in the dam as random rock fill on the downstream side of the dam and as riprap on the upstream side. The spillway is designed to discharge 47,400 cubic feet per second. Discharge over the spillway would result in tailwater back eddies at the dam. The dam rock fill would be selected and placed to provide the necessary protection for the downstream toe of the dam. A cut and cover outlet works located at the toe of the right abutment on bedrock and firm till, would include a control tower with three control gates 3.75 feet wide by 7.25 feet high, a 9-foot diameter circular concrete conduit transitions and stilling basin. Two small multiple-stage outlets with facilities for reoxygenation would be provided for low flow control. An earth dike would be constructed to the height of the dam across a low point of the left valley rim located about 2,500 feet southwest of the dam site. Storage data for Patoka Reservoir are given in the following tabulation:

Pool	Elevation (ft.M.S.L.)	Capacity (acre-feet)	Capacity inches runoff	Area (acres)	Length of pool main stream (miles)
Minimum	506	13,200	1.47	2,010	11
Conservation	506-536	167,500	18.70	8,880	25
Flood Control	536-550	144,100	16.08	11,760	31
Total Storage	550	324,800	36.25	11,760	31

The Bureau of Outdoor Recreation (Appendix F, Exhibit F-4) has indicated that a total of 4,000 acres of land would be required for present and future general recreation use. It is estimated that about 1,100 acres of normal project land acquisition would apply to this requirement and that fee acquisition of an additional 2,900 acres would meet this general recreation requirement. All of the project lands, including those adjacent to the tailwater, would be available for general recreation, and fishing and hunting. The specific areas for the various recreational activities would be designated during post-authorization project planning. Facilities for recreational development would include those pertaining to picnicking, fishing, boating, tent camping, swimming and hunting. Selected areas would be designated for commercial concessionaires. The wildlife management of these lands would be compatible

with the project uses for which acquisition would be accomplished. The project plan would provide for an annual recreation visitation increasing from 400,000 to 1,350,000 over the project life. The implementation of the fish and wildlife plan, as recommended by the U. S. Fish and Wildlife Service and presented in this report, would result in an increase in annual use of the area by 121,000 angler days. A total area of 21,900 acres of land would be required for the complete project development, including the recreation as outlined above. These areas would include those required for construction, operation of the flood control pool and permanent structures.

A conservation pool of 167,500 acre-feet would be provided to augment downstream low flows in the interest of water supply and water quality control, in accordance with the recommendations of the United States Public Health Service and the desires of the State of Indiana as expressed by the Indiana Flood Control and Water Resources Commission. This storage is sufficient to provide continuous coincident flows for water supply and water quality control of 130 cubic feet per second and 68 cubic feet per second, at Jasper, respectively.

The total estimated cost of the Patoka Reservoir is $24,000,000. Pertinent data for the project is given in table 9. A map of the reservoir area and area and capacity curves are shown on plate 6. Plan and sections of the proposed structures are shown on plate 7. Detailed descriptions of the topography and geology of the dam site are given in Appendix E.

(2) Foundations. Preliminary reconnaissance in the reservoir area was accomplished by the Indiana Flood Control and Water Resources Commission and the site proposed herein was suggested by the Flood Control Commission. Corps of Engineers investigations have demonstrated general competence of the dam site foundations and were concentrated on ground water studies and other determinations relating to water tightness of the dam foundations. The Flood Control Commission has financed and arranged for accomplishment of explorations supplemental to those of the Corps.

The alluvial valley sand is compact and relatively impervious, overlaying bedrock top layers of sandstone and shale. Top layers of limestone exist in the abutments. About 5 feet of stripping of silty clay would be required under the embankment. To control and limit leakage, relief wells would be installed at the downstream toe of the dam and a 6-foot thick blanket of impervious material would be placed to extend 500 feet upstream from the upstream toe of the dam. No grouting would be required in the valley. A grout curtain from the dike to the spillway will be required to protect the structures and grout curtains into the drainage divides will be required to control leakage. The dam embankment would be constructed of rock excavated from the spillway and soil from the left abutment borrow area, in addition to drain and graded aggregate zone material. The dike would be constructed of soil from the borrow area between the dam and dike. Materials for drains,

bedding layers, graded aggregate zones and concrete would be obtained commercially. In the spillway excavation large mud seams should be expected in the limestone. When exposed to weathering the indurated clay at the crest will completely break down. A concrete control structure will be required to maintain the spillway crest elevation.

(3) Lands and damages. The major portion of the lands required for the project are presently in grass and grown up pasture with limited cattle operations. While the land appears to be suitable for cultivation, poor drainage with frequent flooding during the crop season greatly diminishes the utility of this land. Access is generally good over county roads. Approximately 160 families reside within the reservoir area. A gross appraisal of all lands and damages in connection with construction of Patoka Reservoir is $3,060,000. The detailed breakdown of the gross appraisal is given in Appendix A.

(4) Relocations. Relocations or alterations would be required for approximately six miles of State highways, 3 miles of Federal-aid secondary roads and 5 miles of county roads. There are about 16 miles of power lines and about 14 miles of telephone lines that would require some alterations. Five cemeteries containing about 400 graves would be moved. Summary of relocations required for the Patoka Reservoir is shown in the pertinent data table 9. Location of the existing and proposed road relocations are shown on plate 6.

d. Real estate criteria. Land required for the projects herein will be acquired in fee simple for the following purposes:

(1) The dam site, construction areas, and permanent structures.

(2) The reservoir area up to an elevation which allows a selected freeboard above the flood control pool, to provide for adverse effects of saturation, wave action and bank erosion.

(3) Where freeboard does not provide a minimum of 300 feet horizontally from the flood control pool, it will be increased to that extent.

(4) Selected sites along the shoreline to meet present and future requirements for outdoor recreation.

A real estate cost estimate was made for each of the three reservoir projects proposed herein. These cost estimates included cost for the following real estate phases of the projects: (a) acquisition at fair market value of all necessary lands and improvements in fee simple (b) damages to property resulting from severance, when applicable, and impairment of access to portions remaining, (c) resettlement costs by persons involved in locating and moving to another place, (d) contingencies for change in market conditions, excessive court awards and other expenses not specifically anticipated or itemized.

The detailed real estate cost estimates for the reservoir projects proposed herein are presented in Appendix A.

Values of lands and damages were determined by appraisals based on field reconnaissance, recent sales and county records. Severance damages were estimated by field reconnaissance. Resettlement costs and contingency estimates are based on past experience for similar projects.

e. Relocations. Relocation studies for roads affected by the proposed reservoirs were based on the criteria which have been used previously in studies and actual construction of water resource projects in the States of Indiana and Illinois. All State and Federal highways within the reservoir will be raised or relocated above the flood control pool level. County roads which cross the reservoir area and are to remain in use after project completion, or access roads to areas that otherwise would be isolated by high pool stages, would be raised or relocated to the level of the flood control pool. All roads that require relocation or alteration under the basic criteria would be constructed to the design standards comparable to those of the State for the traffic existing at the time of taking in accordance with the provisions of Section 207, Public Law 86-645, approved 14 July 1960. Where properties abutting county roads would be purchased and the need for the roads would cease to exist when the project is completed, the affected roads would be abandoned. Studies indicate that the additional cost of overland transportation due to relocation and abandonment of existing roads at the proposed reservoir projects would be more than offset by the proposed improved facilities.

A summary of relocations required for the three reservoirs is shown in pertinent data, table 9.

f. Method of operation. During periods of storm runoff, the reservoirs considered in this report would be operated with the objective of limiting flood storage releases to rates that would not exceed control stages at downstream key points. The reservoirs would be operated as a part of integrated flood control systems of the Wabash and Ohio River Basins. Flood control space is superimposed on a minimum pool level at Clifty Creek Reservoir which makes allowance for silt accumulation during the project life. At Lincoln Reservoir flood control space is superimposed on an additional small storage allocation designed to provide a specified minimum regulated flow in the interests of water supply and water quality control, and at Patoka Reservoir flood control space is superimposed on a substantial conservation storage allocation for these purposes. Conservation storage at Lincoln and Patoka would be operated during periods of low run-off to provide the minimum flows for which they were designed. At Clifty Creek project, maintenance of the minimum pool level would be the objective during the winter months, 1 December through 1 April, in order to provide maximum storage for flood control. At Lincoln and Patoka projects maintenance of conservation pool levels through these winter periods would be the objective. During the summer months, about 1 May to 1 September, when the flood threat has lessened, Clifty Creek and Lincoln

Reservoir pools would be raised to seasonal pool levels higher than the winter pool objectives to increase the recreation potentials of these projects. Seasonal pool heights proposed are dependent on summer run-off and would be achieved three years out of four. Water surface areas available for summer recreation would be increased about 50 percent thereby. Proposed reservoir regulation plans and other data related to the operation of the reservoirs are given in Appendix D.

TABLE 9

PERTINENT DATA - LINCOLN, CLIFTY CREEK & PATOKA RESERVOIRS

Item	Lincoln Reservoir				Clifty Creek Reservoir				Patoka Reservoir			
Location:												
Stream	EMBARRASS RIVER				CLIFTY CREEK				PATOKA RIVER			
River Mile	103.1				18.4				118.3			
Total drainage area, sq. miles	2,438				200				860			
Drainage area, above dam, sq. mi.	915				140				168			
			Capacity				Capacity				Capacity	
	Elev (ft)	Area (acres)	Acre feet	Inches	Elev (ft)	Area (acres)	Acre feet	Inches	Elev (ft)	Area (acres)	Acre feet	Inches
Reservoir:												
Top of minimum pool	582.4	4,050	55,015	1.13	705	548	7,655	1.03	506	2,010	13,200	1.47
Top of conservation pool	584	4,310	61,315	1.26					536	8,880	180,700	20.17
Top of seasonal pool	596	6,760	126,765	2.60	720	919	18,515	2.48				
Spillway crest	629	-	-	-	717	-	-	-	550	-	-	-
Top of flood control pool	629	21,250	538,300	11.03	745	2,390	56,208	7.54	550	11,760	324,800	36.25
Top of spillway gates	-	-	-	-	-	-	-	-	-	-	-	-
Maximum water surface	629	21,250	538,300	11.03		2,390	56,208	7.54	550	11,760	324,800	36.25
Allocated flood control storage	629	21,250	476,985	9.77	745	2,390	48,553	6.51	550	11,760	144,100	16.08
Dam:												
Type of dam	Earthfill				Earthfill and concrete-gravity				Earthfill			
Total length, feet	2,400				7,000				2,500			
Top elevation	648				753				565			
Embankment section:												
Type	Rolled earthfill				Rolled earthfill				Rolled rock and earthfill			
Total length, feet	2,400				6,388				2,500			
Maximum height, feet	110				88				89			
Freeboard, feet	4.9				5				5.4			

TABLE 9
(CONT'D)

Item	Lincoln Reservoir	Clifty Creek Reservoir	Patoka Reservoir
Dam (Cont'd):			
Embankment section (Cont'd):			
Crown width, feet	30	30	30
Side slopes	Varies from 1 on 2.5 to 1 on 3.5	Varies from 1 on 2.5 to 1 on 3.5	Varies from 1 on 2.5 to 1 on 3.5
Non-overflow section:			
Type	-	Concrete gravity	-
Total length, feet	-	472	-
Top width, feet	-	20	-
Spillway section:			
Type & Location	Open cut thru left abutment	Concrete Ogee	Open cut thru right abutment
Total crest length, feet	100	140	400
Net crest length, feet	100	120	400
Length along spillway, feet	2,000	-	1,300
Gates:			
Type	-	Tainter	-
Number	-	3	-
Size (width x height), feet	-	40x28	-
Capacity, cubic feet per second:			
Maximum discharge, c.f.s.	-	71,700	-

TABLE 9
(CONT'D)

Item	Lincoln Reservoir	Clifty Creek Reservoir		Patoka Reservoir
Outlet Works:				
Type	Gate controlled conduit	Gate controlled sluices		Gate controlled conduit
Number of conduits	1	2		1
Dimensions, feet	10' Dia.	4x6 (wxh)		9' Dia.
Invert elevation, feet	540	666		481.1
Control	3-4'Wx8'H	2-4'Wx6'H		3-3'9"Wx7'3"H
Capacity, cubic feet per second:				
Top of flood control pool	3,980	2,860		2,640
Top of minimum pool	2,650	1,960		1,350
Other structures:		Dike	Hartsville Levee	
Dike		Earth	Earth	Earth
Length, feet	-	3,500	3,500	1,560
Top elevation	-	753	753	565
Maximum height, feet	-	8	33	35
Crown width, feet	-	12	12	30
Slopes	-	1 on 2.5	1 on 3	1 on 3
Spillway design flood:				
Peak inflow, cubic ft. per second	125,200		71,000	183,000
Volume, acre-feet	741,700		110,530	187,710
Volume, inches	15.20		14.82	20.95
Peak outflow, cubic ft. per second	14,450		63,200	50,000

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TABLE 9
(CONT'D)

Item	Lincoln Reservoir	Clifty Creek Reservoir	Patoka Reservoir
Relocations:			
Railroads, miles	3.03	-	-
U.S. Highways, miles		-	-
State highways, miles	1.92	4.3	5 86
Federal Aid Secondary roads, miles	1.56	-	2.82
County and other roads, miles	1.88	0.85	4.94
Power lines, miles	6.02	11	15.62
Telephone lines, miles	6.02	11	13.62
Pipe lines, miles	-	-	-
Cemeteries, number of graves	440	723	410
Towns, number		-	
Land:			
Fee acquisition, acres:			
Flood control	35,500	3,280	19,000
General recreation 1/	3,300	600	2,900
Total	38,800	3,880	21,900

1/ Additional land

SECTION VII - ECONOMICS OF RESERVOIR PLANS

31. ESTIMATES OF FIRST COST.

The total estimated first cost of construction of Lincoln, Clifty Creek and Patoka Reservoir projects, based on unit prices prevailing in December 1963, are $33,000,000, $15,900,000, and $24,000,000 respectively. The future increments of recreation, contingencies, engineering and design, and supervision and administration are included in these totals. Contingency amounts are based on the degree of adequacy of specific information on which the estimates for specific items are based. Engineering and design and supervision and administration amounts are based on cost experience for similar work. A summary of the first costs for each project is given in table 11. Detailed estimates of first costs are shown in Appendix A.

32. ESTIMATES OF ANNUAL CHARGES.

Financial and economic costs, investment and annual costs for each of the three multiple purpose reservoir projects are given in table 12. The investment includes the total first cost plus interest for this amount over one-half of an estimated four-year construction period. The amortization amount is based on an interest rate of 3 percent and a useful project life of 100 years. Costs are included as a separate item for major replacement of those portions of the project that are expected to have a physical life of less than 100 years. Allowance for loss of land productivity is based on 5 percent annual net income on reservoir lands. Detailed estimates of annual costs for Lincoln, Clifty Creek and Patoka Reservoirs are given in Appendix A.

Area Redevelopment Act effects as a reduction in economic costs are summarized as follows:

The value of wages paid for the construction, operation and maintenance of the proposed projects to persons otherwise unemployed who live in Redevelopment Counties within commuting distance is credited to each project as a reduction of the economic costs. The values computed for the initial phase of construction of the projects were converted to average annual equivalent values by compound interest methods. All ARA wage expenditures for construction, operation and maintenance of the future increment of recreation and for operation and maintenance of the initial increment were discounted, with the assumption that employment opportunities would increase, without the projects, to full employment 20 years after completion of initial construction. These discounted values were then converted to average annual equivalent values by compound interest methods. The value of labor costs and skill requirements is based upon office studies of recent detailed cost estimates of Monroe and Barren Reservoirs. A summary of labor costs and skill requirements is presented in table 10.

TAPLE 10

AREA REDEVELOPMENT ACT EFFECTS AS REDUCTION
OF ANNUAL ECONOMIC COSTS

Reservoir Project	ARA Wage Expenditures		
	Construction	Operation & Maintenance	Total
Lincoln	$70,000	$21,000	$91,000
Clifty Creek 1/	-	-	-
Patoka	62,000	23,000	85,000

1/ Clifty Creek Reservoir not affected by provisions of Area Redevelopment Act.

TABLE 11

SUMMARY OF ESTIMATED FINANCIAL FIRST COSTS LINCOIN, CLIFTY CREEK AND PATOKA MULTIPLE PURPOSE RESERVOIR PROJECTS

(Based on unit prices prevailing in December 1963)

Item	Lincoln Reservoir	Clifty Creek Reservoir	Patoka Reservoir
Lands and damages	$12,800,000	$ 1,810,000	$ 3,060,000
Relocations	8,200,000	2,250,000	5,150,000
Reservoir	1,790,000	140,000	800,000
Dam and appurtenances	3,640,000	6,380,000	7,170,000
Levees	-	290,000	-
General recreation 1/	3,790,000	2,870,000	4,730,000
Fish and wildlife	125,000	110,000	200,000
Buildings, grounds and utilities	100,000	100,000	100,000
Permanent operating equipment	70,000	75,000	70,000
Engineering and design	1,185,000	912,000	1,285,000
Supervision and administration	1,300,000	963,000	1,435,000
Total estimated cost 2/	$33,000,000	$15,900,000	$24,000,000

1/ Includes future increment of recreation

2/ Preauthorization cost of $35,000 for each reservoir project is not included.

TABLE 12

SUMMARY OF FINANCIAL AND ECONOMIC ANNUAL COSTS
LINCOLN, CLIFTY CREEK AND PATOKA MULTI-PURPOSE RESERVOIR PROJECTS
(IN THOUSANDS OF DOLLARS)
(ROUNDED)

	LINCOLN RESERVOIR		CLIFTY CK. RESERVOIR		PATOKA RESERVOIR	
	Financial	Economic	Financial	Economic	Financial	Economic
INITIAL PROJECT						
Investment						
First cost	30,720	30,720	13,860	13,860	20,440	20,440
Interest during constr.	1,843	1,843	832	832	1,226	1,226
Gross investment	32,563	32,563	14,692	14,692	21,666	21,666
Annual costs						
Interest	977	977	441	441	650	650
Adjustment for net loss in productivity of reservoir lands		198		19		28
Amortization	54	54	24	24	36	36
Maintenance & Operation	144	144	93	93	141	141
Major replacements	21	21	18	18	19	19
Total initial annual costs	1,196	1,394	576	595	846	874

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TABLE 12 (Cont'd)

	LINCOLN RESERVOIR		CLIFTY CK. RESERVOIR		PATOKA RESERVOIR	
	Financial	Economic	Financial	Economic	Financial	Economic
FUTURE RECREATION INCREMENT						
Investment	2,280	2,280	2,040	2,040	3,560	3,560
Annual costs						
Interest	68	68	61	61	107	107
Amortization	4	4	3	3	6	6
Maintenance & operation	140	140	121	121	201	201
Major replacements	19	19	17	17	30	30
Subtotal	231	231	202	202	344	344
Present worth - 100 year accelerated growth at 3%	150	150	131	131	224	224
APA ECONOMIC COST REDUCTIONS	-	91	-	-	-	85
TOTAL GROSS INVESTMENT	34,843	34,843	16,732	16,732	25,226	25,226
TOTAL ANNUAL COSTS	1,346	1,453	707	726	1,070	1,013

33. ESTIMATES OF BENEFITS.

a. General. Estimates of flood control benefits to the proposed improvements were developed by use of standard methods and procedures used by Corps of Engineers in project development. Determination of general recreation, fish and wildlife recreation, water supply and water quality control benefits were made in conjunction with studies conducted by other agencies. A brief description of benefits to the proposed reservoirs is given in the following paragraphs and summarized in table 13. No system analysis was made of the reservoirs. In the area of common influence along the Wabash River, the sum of the stage reductions afforded by the three reservoirs for a flood with a frequency of once in 50 years on the Mount Carmel gage is about 0.3 foot.

b. Flood Control.

(1) Tangible benefits. Flood control benefits that are credited to Lincoln, Clifty Creek and Patoka Reservoirs are the differences in tangible annual flood losses between present conditions of flooding and those expected with these reservoirs in operation. In determining the value of present annual losses, consideration was given to the beneficial effects of both existing reservoirs and those under construction, and to the operation of local protection projects that are existing, under construction or in the advanced design stage. Authorized levee projects were considered on the basis of a logical schedule of construction and it was determined that there would be no appreciable effect on the economics of these projects over the life of the reservoirs.

Tangible benefits to the studied reservoirs were determined by the damage-frequency procedure of analysis. Benefits to each reservoir were computed independently of the other two reservoirs. A summary of these benefits is presented in table 13. Additional data on development of tangible benefits are given in Appendix B.

(2) Intangible benefits. These benefits, although not monetarily evaluated, are of importance in the study area. These proposed reservoirs, in conjunction with other flood protection works, will assist in reducing flood stages and durations downstream from the dam sites. This will decrease the potential hazards that accompany flooding, such as loss of life, contraction of epidemic diseases, and deterioration of health from unnatural exposures. The general health and well being of the persons who reside in the overflow area will be enhanced.

c. Future growth. Several studies have been made as to the future economic growth in the Wabash River and Ohio River Basins. These studies are based primarily on population trends and predicted employment. It is considered a conservative estimate to assume that a 200 percent growth in the overflow areas of the Wabash River Basin and a 150 percent growth in the lower Ohio River overflow area will occur during the 100-year project life, regardless of the development

of flood control projects. Using a long term interest rate of three percent, the average annual equivalent factors for the 200 and 150 percent increases are 0.57688 and 0.43266, respectively. Flood prevention benefits to the Wabash River and tributaries and the lower Ohio River were increased by the appropriate factor to include benefits for this future growth. Development of the estimates of annual growth factors is given in Appendix B.

d. General recreation. The Bureau of Outdoor Recreation made a study of the recreation potential at each of the proposed reservoir sites. From these studies estimates were made of expected annual recreation visitation at each site for two stages of development. The initial stage is the attendance which could be expected in the first five years of project operation. The future increment stages of development would provide for an attendance that could be expected to occur at some future time during the project life. Recreational benefits were computed on the basis of $1.00 per visitor day of recreation with the benefits to the future increment being discounted to present value by an average annual equivalent factor. For this report the future increment of attendance will be achieved along an accelerated growth curve over the 100-year project life. General recreation benefits to the proposed reservoir are summarized in table 13. The Bureau of Outdoor Recreation's report is presented in Appendix F, Exhibit F-4.

e. Fish and wildlife recreation. Reports prepared by the U. S. Fish and Wildlife Service which analyzed the effects of the recommended projects on fish and wildlife resources, are presented in Appendix F, Exhibit F-3. The benefits for this purpose are stated in terms of the net increase of hunter and fisherman visitations at each reservoir site, assuming implementation of the fish and wildlife plans. These benefits are summarized as a part of table 13.

f. Water supply and water quality control. The U. S. Public Health Service has evaluated the needs for water supply storage and water quality control storage at the proposed reservoir as indicated in Appendix F, Exhibit F-6. The water supply and water quality control needs considered for solution by the reservoirs are discussed in Section V and the benefits briefly described in the following paragraphs. Since the water quality control releases from Lincoln and Patoka Reservoirs are assumed to continue downstream undiminished, the benefits therefrom are considered to be widespread and to be a Federal responsibility.

(1) Lincoln Reservoir. Storage of 5,300 acre-feet has been allocated to water supply and water quality control to meet low flow objectives along the Embarrass and Wabash Rivers. The benefits attributable are computed as the alternate cost of meeting these requirements by single purpose projects at the Lincoln Reservoir site and are estimated at $44,000 and $11,000 annually, for water quality control and water supply, respectively.

(2) Clifty Creek Reservoir. No initial water conservation storage included in project plan.

(3) Patoka Reservoir. Benefits for water quality control and water supply have been determined as equal to the cost of construction and operation of alternate single purpose reservoirs which would provide the same downstream flows as the multi-purpose plan. These benefits are estimated at $219,000 for water quality control and $344,000 for water supply, annually. Additional data is presented in Appendix B.

g. Summary of benefits. Construction of the three proposed reservoirs will substantially reduce flood damages in the areas below the reservoirs and in conjunction with existing reservoirs and those under construction will assist in reducing flood damages along the Wabash and lower Ohio Rivers. Benefits to general recreation will accrue as a result of the provision of water areas and recreation facilities at and adjacent to the reservoirs. Fish and wildlife recreation will be enhanced by pool and tail water fishing. Additional storage will be provided in Lincoln and Patoka Reservoirs for water supply and water quality control. Summarized in table 13 are the estimated benefits that will accrue to the proposed reservoirs.

TABLE 13. SUMMARY OF ANNUAL BENEFITS OF RESERVOIR PROJECTS

Item of benefit	Reservoir benefit ($1,000) Lincoln	Clifty Creek	Patoka
Flood control			
Present	1,200 (1)	349	330
Future growth	690	201	190
Subtotal, flood control	1,890	550	520
Recreation			
General			
Initial	425	200	400
Future increment (2)	440	391	619
Subtotal, general recreation	865	591	1,019
Fish and wildlife	99	26	130
Subtotal, recreation	964	617	1,149
Water supply	11	-	344
Water quality control	44	-	219
TOTAL BENEFITS	2,909	1,167	2,232

(1) Includes $16,000 benefits along the Ohio River.
(2) Discounted to present value

34. ECONOMIC JUSTIFICATION.

The three reservoirs studied for this report are each justified on the basis of tangible benefits which will accrue from its operation. Likewise, each purpose of the multiple purpose projects is justified on the same basis. Table 14 summarizes the estimated average annual benefits and charges of each project and each project purpose.

TABLE 14. COMPARISON OF BENEFITS AND COSTS FOR RESERVOIR PROJECTS

Reservoir and purpose	Annual benefits ($1,000)	Annual costs (1) ($1,000)	Benefit to cost ratio
Lincoln			
Multiple purpose	2,909	1,453	2.0
Flood control	1,890	781	2.4
Recreation (2)	964	531	1.8
Water supply	11	9	1.2
Water quality control	44	25	1.8
Clifty Creek			
Multiple purpose	1,167	726	1.6
Flood control	550	404	1.4
Recreation (2)	617	303	2.0
Patoka			
Multiple purpose	2,232	1,013	2.2
Flood control	520	254	2.0
Recreation (2)	1,149	575	2.0
Water supply	344	145	2.3
Water quality control	219	96	2.3

(1) Multiple purpose annual costs are total annual economic costs; annual costs for separate purposes are based on total allocated financial costs.

(2) Includes initial and future increment stages of general recreation and fish and wildlife recreation.

Recreation costs and benefits used in project analysis include costs at each site for two stages of development. The initial stages include the total real estate costs for that purpose and the costs of

facilities which would be required in the first five years of project operation. The future increment stages include the estimated costs of additional facilities to meet public needs during the entire project life. The future incremental costs are discounted to present value by an average annual equivalent factor based on 100-year accelerated growth. The recreation costs are based on studies of the recreation potential at each of the proposed reservoir sites by the Bureau of Outdoor Recreation. The Bureau of Outdoor Recreation's report is included as a part of Appendix F.

35. PROJECT FORMULATION.

The Wabash River Basin, including the White River Basin, has been subject to frequent floods of long duration for many years. A system of agricultural levees, local urban protection projects, and reservoirs has been formulated during past investigations which partially meets the needs of the basin. The locations of the authorized, under construction and recommended projects are shown on plate 1 and discussed elsewhere in this report. Flood protection and allied benefits are provided by these projects. However, as indicated in the preceding table 6, the residual flood damages, with consideration given to the reservoirs and levee projects expected to be in operation in the near future along the reaches downstream from the proposed Lincoln, Clifty Creek, and Patoka Reservoirs, amount to an average of $8,297,000, annually. Reduction of these flood damages appears to be the most pressing water resources problem in the basin at this time. Sequential development of the basin resources to reduce these damages is in accordance with the expressed desires of State and other public officials and local interests. Preliminary studies of many possible reservoir sites throughout the basin indicate that the immediate and near future needs are most urgent for the projects developed in this report. The sites recommended, as discussed in other sections and appendices, are considered to be the most reasonable and practical.

In addition to flood control needs cited above, formulation of the project features of Lincoln, Clifty Creek and Patoka Reservoirs has given consideration to multiple purpose use to serve indicated needs for water supply, water quality control, recreation and fish and wildlife. With the possible exception of water supply storage proposed at the Patoka site, data developed for project purposes other than flood control as to needs and values are preliminary at this time. This is due, primarily, to need for reexamination in relation to accomplishments of other projects, as yet unidentified, which will be elements of the comprehensive basin plan. Benefit evaluations are, however, conservative. In view of this situation it has not been deemed necessary or appropriate to consider a range of capacities or values for certain functions, such as recreation, where small changes in governing pool levels would have no significant effect on overall project scope. Such studies, for the projects concerned herein can best be accomplished, depending on project authorization, during more detailed pre-construction planning.

Lincoln Reservoir site, as discussed in paragraph 28, is the most suitable site in the Embarrass River basin, an area characterized by a lack of reservoir storage opportunities. Maximum flood control pool elevation selected for the project conforms to the level recommended in 1944 as a result of detailed studies performed when the project was in authorized status. This pool level would provide maximum practicable storage without serious effect on the better farmlands in the upper reaches of the reservoir. The selected minimum pool elevation is based on a suitable allowance for silt accumulation and the conservation pool, 1.6 feet above the minimum pool, provides for storage above the minimum pool level to meet preliminary estimates of water supply and water quality needs.

In accordance with design of other projects in the Wabash Basin, and because the summer flood potential is less than that of the winter season, it would be practicable to establish a summer seasonal pool somewhat higher than the conservation pool in the interests of recreation and fish and wildlife. This seasonal pool, as limited by summer runoff, is that which can be achieved three years out of four, and involves no significant costs as it falls within the flood control storage range. In the case of Lincoln the seasonal pool level would be some 12 feet higher than the conservation pool and would afford about 2,000 acres of additional pool area.

Within the limits of storage proposed herein for the Lincoln Reservoir, studies of lesser amounts of flood control storage were made. While these studies indicated that the top increment of storage for flood control would have a benefit-cost ratio slightly less than unity, control of the flood of record is considered to be an overriding factor in avoidance of a false sense of security, and to fully justify the storage proposed. Loss of life in Newton, Illinois, resulted from the 1950 flood. As noted on page 66 the project as formulated and all project functions are well justified. In further support of the storage proposed, maximum development of the storage potential of the site as proposed is desirable because of the lack of other storage potentials in the area and to provide flexibility for future increases in conservation storage allocations for irrigation or other needs not now foreseen on the basis of preliminary appraisals.

The capacity of Clifty Creek Reservoir is limited, by the town of Hartsville, to an amount less than would be desirable for flood control. Accordingly, to realize the maximum use of the available capacity, a gate-controlled spillway is proposed so that pool rise to pass floods exceeding the reservoir's capacity is largely eliminated. The project as proposed would control a flood of 50-year average frequency. The minimum pool level has been set, in the interest of providing maximum active storage space, at the lowest level consistent with proper allowance for siltation. The minimum pool level establishes the elevation of the seasonal pool, which is provided in the interest of recreation and can be filled three years out of four, dependent on volume of summer runoff.

Present formulation of Clifty Creek Reservoir is based on flood control, recreation and fish and wildlife purposes as outlined above. Other agencies have, however, indicated future needs for water quality and irrigation storage. These needs are discussed in Section V and Appendix F. In one case the Public Health Service proposes use of seasonal storage for water quality control. Such use would be at the expense of greater benefits for recreation and accordingly is not now proposed. No value is presently available for storage for irrigation, and this purpose has not been considered at this time. With respect to conservation storage in general, however, it should be noted that development of the comprehensive plan for the Wabash Basin will involve consideration of alternate sites in the vicinity of, and upstream from, Clifty Creek. In the event that additional feasible reservoir projects in the area are identified in the future, consideration will be given to reallocation of Clifty Creek storage in accordance with its most beneficial use as then determined, and conservation storage in the reservoir may then be shown to be practicable.

Purposes of Patoka Reservoir involved in project formulation are flood control, water supply, water quality control, recreation, and wildlife conservation. This project has been under study by the Indiana Flood Control and Water Resources Commission which supports project storage capacities presented herein, involving conservation storage in the amount of 167,500 acre feet for water supply and incidental water quality control. Provision of storage for water quality control can, however, be a Federal responsibility and the preliminary report by the U. S. Public Health Service (Appendix F, Exhibit F-6) outlines a need and value, and Federal responsibility therefor, in Patoka River. This responsibility is recognized by the Indiana Flood Control and Water Resources Commission and their assurances as to reimbursement for water supply storage, although expressing interest in State control of the total conservation storage of 167,500 acre-feet, contains a proviso that studies now underway and future legislative action may indicate that State responsibility for water quality control storage is undesirable or impossible. The State will, however, assume responsibility for costs of that portion of the 167,500 acre-feet allocated to water supply. Accordingly, costs of this storage have been allocated to both water quality, at Federal cost, and water supply, at State cost. All concerned concur that the amount of storage provided, approaching that required for complete regulation of runoff above the dam site, is desirable.

Flood control storage at Patoka Reservoir site would be superimposed on the conservation storage discussed in the preceding paragraph. The amount proposed would control the maximum flood of record, and, in conjunction with proposed conservation and sediment storage, would fully utilize the storage potential of the Patoka site. Further, on the basis of incremental analysis, benefits of the top increment of flood control storage exceed costs thereof. Accordingly, with respect to flood control and conservation storage, development of Patoka Reservoir site as proposed herein is considered to be at optimum level.

Development of the project in the interest of recreation and fish and wildlife hinges primarily in the pool level existing during the summer recreation season. Regulation studies using the conservation storage proposed indicate that little pool variation from that for the top of this storage reservation will occur during this period. As limited by the storage capability of the reservoir site and provision of necessary flood control space, the project as proposed achieves a summer pool area of about 8,000 acres and this is considered to be a practical maximum as far as recreation and fish and wildlife benefits are concerned.

The Federal Power Commission has indicated, as shown in Appendix F, that although hydroelectric power is not economically feasible at this time for any of the three reservoirs, this feature should be re-examined in later detailed design studies.

As shown in Table 14, preceding, each project and each purpose is justified by a wide margin. Since the maximum capabilities of the best reservoir sites in the areas considered are proposed to be developed, the plan herein is considered to be compatible with the over-all development of the water resources of the Wabash River Basin.

SECTION VIII - ALLOCATION AND APPORTIONMENT OF COSTS

36. ALLOCATION OF COSTS BETWEEN PURPOSES.

Allocations of costs for each reservoir project have been made to obtain an equitable distribution of costs among purposes served. Project costs were allocated by the separable costs-remaining benefits method. Estimated costs for the future increments of general recreation use have been reduced to average annual equivalent values by compound interest methods. A summary of annual financial costs allocated to each project purpose is presented in Table 15. The costs and procedures used in determining the cost allocations are given in Appendix C.

TABLE 15

ALLOCATION OF ANNUAL COSTS FOR RESERVOIRS CONSIDERED ($1,000)

	Investment			Operation, Maintenance & Major Replacement			Financial		
	Separable	Joint	Total	Separable	Joint	Total	Separable	Joint	Total
Lincoln Reservoir									
Flood control	606	144	750	20	11	31	626	155	781
Water quality control	9	15	24	0	1	1	9	16	25
Water supply	7	2	9	0	0	0	7	2	9
Recreation	147	148	295	225	11	236	372	159	531
Total	769	309	1078	245	23	268	1014	332	1346
Clifty Creek Reservoir									
Flood control	223	143	366	24	14	38	247	157	404
Recreation	95	46	141	158	4	162	253	50	303
Total	319	189	507	182	18	200	500	207	707
Patoka Reservoir									
Flood control	196	39	235	10	9	19	206	48	254
Water quality control	60	30	90	-	6	6	60	36	96
Water supply	87	48	135	-	10	10	87	58	145
Recreation	240	59	299	263	13	276	503	72	575
Total	583	176	759	273	38	311	856	214	1070

37. APPORTIONMENT OF COSTS.

a. General. Costs for features incorporated into the multiple purpose reservoirs are the responsibility of both Federal and non-Federal interests. In accordance with general policy expressed in applicable legislation, the allocated costs for project features have been apportioned between Federal and non-Federal interests.

b. Flood control costs. All costs allocated to flood control storage in the three multiple purpose projects are a Federal responsibility in accordance with flood control law.

c. Water quality control costs. All costs of storage for water quality control in Lincoln and Patoka Reservoirs, because of widespread benefits, are the responsibility of the Federal government in accordance with the Federal Water Pollution Control Act, Amendments of 1961.

d. Water supply costs.

(1) Lincoln Reservoir. All costs apportioned to water supply storage included in Lincoln Reservoir are the responsibility of non-Federal interests in accordance with the Water Supply Act of 1958 (Title III of Public Law 85-500). The non-Federal share of first costs is 0.75 percent of the total construction costs, or $249,000. Operation, mainrenance and major replacement costs allocated to this function are too small to be listed separately and the annual equivalents have been included in the construction costs.

(2) Patoka Reservoir. All costs allocated to water supply storage in the Patoka Reservoir are apportioned to non-Federal interests in accordance with the Water Supply Act of 1958 (Title III of Public Law 85-500). The non-Federal share of first costs is 15.24 percent of the total construction costs or $3,658,000. The non-Federal share of annual operation, maintenance and major replacement costs is 3 percent of the total or $10,000. The present value of a lump sum payment of these operation, maintenance and major replacement costs is currently estimated to be $316,000.

e. General and fish and wildlife recreation costs. In accordance with present cost sharing procedure as recommended by H. R. 9032, Section 1 (c), 88th Congress all costs associated with this feature are apportioned to the Federal Government.

SECTION IX - PROPOSED LOCAL COOPERATION

38. FLOOD CONTROL.

In accordance with long-standing standard practice, all costs attributable to flood control in a multiple purpose project are a Federal responsibility. Benefits creditable to flood control expressed as a percentage of total project costs for Lincoln, Clifty Creek and Patoka Reservoirs are 129, 75, and 50, respectively.

In order to maintain the flood control effectiveness of the reservoirs considered in this report, local interests should be charged with the responsibility of preventing encroachments and obstructions which would reduce the flow-carrying capacities of the channels downstream of the dams on the Embarrass River, Clifty Creek and Patoka River.

39. GENERAL RECREATION.

In accordance with standard practice, the costs for general recreation facilities required to provide for public access to and full recreation use of project impoundments are Federal costs. The benefits claimed are both widespread and regional in nature.

40. FISH AND WILDLIFE RECREATION.

No reimbursements or other items of local cooperation toward fish and wildlife facilities are proposed for the three reservoir projects considered herein. It is considered that the additional cost to the Federal government for including Fish and Wildlife Recreation features in the reservoir project plans is consistent with the regional nature of the benefits to be derived from the use of these facilities. The amount of joint project costs for Lincoln, Clifty and Patoka Reservoirs allocated to general recreation and fish and wildlife is estimated at about 12, 2 and 3 percent of the total project costs of these projects, respectively.

41. WATER SUPPLY.

Repayment of costs allocated to water supply storage is an item of local cooperation. Inclusion of water supply as a purpose of the Patoka and Lincoln Reservoirs proposed herein has been discussed elsewhere in this report. Repayment of construction and annual costs allocated to water supply may be made either in lump sum amounts or in annual payments beginning with use. In the case of future use, a 10-year interest free period is allowed in establishing the costs to be returned.

In the case of Lincoln Reservoir the City of Charleston, Illinois, has expressed the intent of purchasing storage in Lincoln Reservoir. Exhibit F-9 of Appendix F is a letter from the Mayor of Charleston conveying this information.

With respect to Patoka Reservoir the State of Indiana, through the Indiana Flood Control and Water Resources Commission, has expressed interest in acquiring rights to the 167,500 acre-feet of storage between minimum pool elevation 506 and conservation pool elevation 536. Their letter on this subject, Exhibit F-10 of Appendix F, cites certain legislative authorities in this regard, including sale of water. The Commission has also made detailed regulation studies using the 167,500 acre-foot storage and strongly advocates development of this total amount in order to fully utilize the storage potential of the reservoir site. The Commission recognizes, however, that a Federal responsibility exists for water quality control on Patoka River and is concerned with coordination of storages and releases for water supply and water quality control. They have, accordingly, set up a special committee to study this situation. In the interim, therefore, the Commission's desire to acquire rights to all of the conservation storage proposed as qualified by the statement that "-----exact division of allocated storage between water supply and water quality control be left for later decision -----". The possibility exists, however, that the State will ultimately desire control of the total conservation storage allocation.

In view of the foregoing and for purposes of this report, cost allocations for Patoka Reservoir include both water supply and water quality control, and water supply costs have been apportioned to the State. No objection is seen to future apportionment to the State of costs allocated to water quality control if they desire to acquire rights to this storage and would operate it in accordance with the water quality control objectives stipulated in this report.

In accordance with the foregoing, apportionment of costs to the State for water supply only would amount to 15.24 percent of the construction costs, or $3,658,000, and 3 percent of the annual operation, maintenance and replacement costs, or $10,000. If the State later elects to acquire rights to storage allocated to water quality control additional costs involved would be 10 percent of construction costs or $2,438,000, and 2 percent of the annual costs for operation, maintenance and replacements.

SECTION X - COORDINATION WITH OTHER AGENCIES

42. GENERAL.

The following paragraphs summarize the reports and studies conducted for this Interim Report by the various Federal and non-Federal agencies that are cooperating in the Wabash River Basin Comprehensive Study. Reports received from the Federal agencies are contained in Appendix F.

43. SOIL CONSERVATION SERVICE.

The Soil Conservation Service, United States Department of Agriculture, has made reconnaissance-type studies of the river basins of the three reservoir projects considered herein and their findings are contained in a sequence of letters included in Appendix F, Exhibit F-1. Brief resumes for each project basin are as follows:

a. Lincoln. Storage opportunities in the Embarrass River Basin above Lincoln Reservoir site are extremely limited; however, eleven small watersheds were evaluated and consideration was given to sixteen potential impoundment sites. Of these, only 9 would provide sufficient floodwater storage for drainage area controlled. These nine show a combined storage of 22,912 acre-feet available for other uses. No assessment has been made of multiple use benefits. Only four of the sites would be affected by Lincoln Reservoir and these were found to be unfeasible with or without Lincoln Reservoir. The principal Soil Conservation Service structural program to alleviate flood and drainage problems would involve channel improvements of upstream tributaries. There is no conflict between Lincoln Reservoir and SCS projects upstream of Lincoln Reservoir for lands that would not normally be acquired for the reservoir project.

b. Clifty Creek. Due to topographic conditions, generally limited flood plain areas and types of projects that can be considered, an upstream watershed project would not be feasible on the main stream area of Clifty Creek. Further consideration will be given to upstream watershed project potentials in the Clifty Creek Watershed, generally above Milford, Indiana, Fall Fork above the Bartholomew-Decatur County line, and on Duck Creek for the Wabash River Basin Comprehensive Study. Clifty Creek Reservoir will not affect these projects. It is recommended that land conservation treatment measures be accelerated to stabilize potential sediment source areas through the reduction of sheet and gully erosion and proper land utilization. Irrigation studies indicate that presently there are 220 acres and 890 acres being irrigated along Clifty Creek and the East Fork of the White River, respectively. There is potential for additional irrigation needs in the Clifty Creek basin. Further irrigation evaluations will be made for the final Wabash River Basin Comprehensive Study Report.

c. Patoka. The portion of the Patoka River Basin considered was that above Jasper, Indiana. Twenty potential upstream impoundment

structures and about 57 miles of channel improvements were considered. The projects are not justifiable on the basis of flood control only. No extensive irrigation requirements along the Patoka River, below the proposed reservoir, are expected to develop in the near future. Future studies will consider additional small watershed project potentials in the Patoka River Basin below Jasper, Indiana.

44. GEOLCGICAL SURVEY

The Geological Survey, United States Department of the Interior, has made preliminary reports on ground water resources of the Embarrass and Patoka River basins and a brief letter report on Clifty Creek basin. These reports are contained in Appendix F, Exhibit F-2 and summarized in the following subparagraphs.

a. Lincoln. The dry-weather yield of the basin is small, especially above the proposed dam site. Ground water quality is generally good but becomes poorer at increasing depths. There are some areas of apparent loss of water from the stream to ground water or by evapo-transpiration above the dam site. Areas of loss coincide, in general, with areas underlain by buried bedrock valleys filled with unconsolidated deposits, indicating that losses may be to these deposits. An area of loss about 1.5 miles above the dam site is located at the intersection of a buried valley with the channel of the Embarrass River. Water lost to this buried valley would probably be returned to the stream below Ste. Marie.

b. Clifty Creek. There are no public water supplies within the basin, but there are three just outside the basin at Columbus, Greensburg, and Hope. Greensburg uses both ground and surface water supply. Other areas use ground water sources. Ground water supplies are generally within 50 feet of the surface; chemical quality is good but decreases with depth. Yields are generally higher in the area at the lower end of the basin, near Columbus, but no definite data are now available as to future adequacy of ground water supply.

c. Patoka. Report conclusion: Because of the lack of natural subsurface storage and permeable aquifers, the only means of obtaining yields greater than 0.6 cubic feet per second, which represents the flow of Patoka River at the dam site that is exceeded 90 percent of the time, is the construction of a reservoir in the basin to store water and improve its quality.

45. FISH AND WILDLIFE SERVICE, BUREAU OF SPORT FISHERIES AND WILDLIFE

The effects of the projects considered herein upon fish and wildlife resources have been evaluated by the Bureau of Sport Fisheries and Wildlife, Fish and Wildlife Service, United States Department of the Interior. A letter report on each of the reservoir projects is included in Appendix F, Exhibit F-3. Recommendations of the reports generally cover detailed matters affecting fish and wildlife resources and are submitted for advance consideration to facilitate post-authorization planning. Copies of the District Engineer's comments on

the recommendations contained in these reports are included with the reports. The District Engineer generally concurs with the Fish and Wildlife Service's recommendations, with the exception of acquisition of wildlife mitigation lands at Patoka Reservoir. Acquisition of the recommended wildlife mitigation lands cannot be justified for the following reasons:

a. Based on an estimated net loss of 392 hunter-days annually due to construction of Patoka Reservoir, cost of the recommended mitigation lands would amount to $30 per hunter-day which is considered excessive.

b. The mitigation land recommendation introduces a concept of replacement-in-kind for each type of pre-project recreation. All recreation shares in the cost of the project. Proposed replacement-in-kind requires that an additional cost be imposed on the recreation purpose of the project. Such costs appear to be broad economic or social costs rather than financial costs in terms of project analysis.

c. It is also considered that significant gains would occur in hunter use of public project lands in contrast to their limited use under private ownership.

Construction of the reservoir projects considered herein would with proper facilities and management, result in substantially increased fishing benefits in the project areas. A summary of the fishery and wildlife data presented by the Fish and Wildlife Service is as follows:

SUMMARY OF FISHERY AND WILDLIFE DATA

Reservoir	Estimated Increase in Annual Angler-Days			Loss in Upland Game Hunting Man-days	Gain in Waterfowl Hunting Man-days	Increase in Hunting Man-days
	Pool(1)	Tail-water(2)	Total			
Lincoln	74,400	10,655	85,055	300	600	300
Clifty Creek	18,850	4,000	22,850	160	100	-
Patoka	106,500	14,420	120,920	2,065	1,673	-

(1) Assuming good fishery management including adequate angler access and facilities, and considering yearly filling frequency fluctuations.

(2) Assuming adequate management facilities, including angler access multiple level outlets and satisfactory volume of releases are provided.

46. BUREAU OF OUTDOOR RECREATION

The recreation potentials of the projects considered herein have been studied by the Bureau of Outdoor Recreation, United States Department of the Interior. Reconnaissance reports on each of the reservoir projects and comments of the Forest Service on the Patoka report, the State of Indiana on the Patoka and Clifty Creek reports, and the State of Illinois on the Lincoln report, are included in Appendix F, Exhibit F-4 and summarized in the following paragraphs.

General recreational activities provided for at the reservoir projects considered herein should include sightseeing, picnicking, swimming, boating and camping activities. The total amount of land required for these activities and the estimated maximum future annual visitation is indicated in the following tabulation:

	Land Required (Acres)[1/]	Estimated Maximum Future Yearly Visitation (People)
Lincoln	5,000	1,100,000
Clifty Creek	600	800,000
Patoka	4,000	1,350,000

1/ Includes normal acquisition for project access in the specific areas proposed for development.

The District Engineer is in general agreement with the proposals of the Bureau of Outdoor Recreation except that part 2 of recommendation B of each report, pertaining to the development and administration of the recreation lands by the State Departments of Conservation and, in the case of Patoka, the United States Forest Service is believed to be a policy matter involving negotiations that can best be accomplished during post-authorization planning.

47. BUREAU OF MINES

The Bureau of Mines, United States Department of the Interior, has made an appraisal of the oil and mineral deposits, present and future oil and mineral production and reciprocal effects of the reservoir projects proposed herein. A brief resume for each project basin is as follows:

a. Lincoln. Mineral commodities produced in the reservoir counties of Coles, Douglas and Cumberland are (1) limestone, (2) sand and gravel and (3) coal. The reservoir area lies about midway between two oil pools that are approximately 20 miles apart.

Limestone quarries producing products valued at $566,000 in 1962 would be inundated at the 629-foot maximum flood control level. Waste stripping could be used by quarry operators to form dikes which would provide protection at seasonal reservoir levels and during minor flood conditions or quarrying can be limited to higher elevations with increase in stripping costs. Consideration should be given to obtaining flowage easements for quarry areas; if agreeable to operators.

No strip coals occur in the reservoir area. The estimated depth of the top coal bed is 960 feet. The overburden over the coal is adequate and sufficiently competent to permit mining under the reservoir provided adequate safeguards are utilized.

There is no oil or gas production in the reservoir area. Lack of oil potential is indicated by the large number of dry wells drilled.

b. Clifty Creek. Clifty Creek Reservoir is in an area of negligible mineral potential. Surface deposits of other than limestone or sand and gravel are not known. The limestone, sand and gravel deposits are not considered commercial. Limestone that has produced oil and gas occurs beneath the reservoir area. Test holes drilled in the reservoir area have been dry holes and all evidence indicates that oil reserves do not exist beneath the reservoir. Possibility of future gas production is considered remote.

c. Patoka. There are no mining or oil production activities in the proposed Patoka Reservoir area. There is some mineral resource potential in the inundated reservoir area. Gypsum and oil are produced in the vicinity of the reservoir area. The reservoir area has been tested for oil and several dry holes have been drilled. Oil drillings have indicated that gypsum beds underlie the reservoir area; but since the present nearby gypsum operations have high-grade gypsum reserves sufficient for many decades, need for gypsum production in the reservoir area is not probable. There is no coal, limestone or other commercial mineral production in the Patoka Reservoir area.

The Bureau of Mines has not indicated any water needs or pollution loads from mining operations or water-flooding oil recovery operations in the areas tributary to the reservoir basins. The complete letter reports from the Bureau of Mines are presented in Appendix F, Exhibit F-5.

48. PUBLIC HEALTH SERVICE

The Public Health Service, United States Department of Health, Education and Welfare has made a general appraisal study of the potential needs and value of water for municipal, industrial and water quality control purposes for the river basins of the three reservoir projects considered herein. The reports on each reservoir project are included in Appendix F, Exhibit F-6. Brief resumes for each project are as follows:

a. Lincoln. Additional municipal and industrial water supply needs in the area above Lincoln Reservoir, principally from the City of Charleston, are predicted, on a preliminary basis by the Public Health Service, to reach 0.7 to 1.5 mgd (million gallons per day) by the year 1976 and 4.4 to 9.6 mgd by the year 2010. For the area below the reservoir, water supply needs are expected to reach 1.2 to 1.5 mgd by 1976 and 2.4 to 2.8 mgd by 2010. It is recommended that the minimum water release for water quality control be at least equal to the minimum

consecutive seven-day average flow having a recurrance of once in 5 years at Newton, Illinois. This is about 21 cubic feet per second.

The proposed plan for Lincoln Reservoir includes storage allocation of 5,300 acre-feet to meet the preliminary objectives cited above, and timing of needs, generally in accordance with dates set forth, has been used in project analysis. The storage indicated is obtainable in 1.6 feet of pool height between minimum and conservation pool levels. If adjustment of this storage is necessary in the future to conform to final water supply and water quality requirements, detailed studies associated therewith will be accomplished in post-authorization planning.

b. Clifty Creek. No needs for water supply storage in Clifty Creek Reservoir are indicated at this time. The City of Hartsville, which has no municipal water supply or sewage disposal systems, is expected to find it necessary to build both utilities if and when Clifty Creek Reservoir is constructed. It is anticipated that Hartsville would be the only community interested in using the reservoir for water supply. Such water supply requirements would have an insignificant effect on reservoir storage since Hartsville's adequately-treated wastes would be returned to the reservoir.

The Public Health Service estimated that a minimum discharge of from 14 to 20 cfs from Clifty Creek Reservoir would be required by the year 2010 for water quality control. This discharge would be needed to assimilate adequately-treated sewage effluent introduced into Clifty Creek below the dam site in order to maintain suitable water quality for water supply for communities downstream on the East Fork White River. This effluent would be discharged from a new plant constructed to serve suburban areas of the City of Columbus in the vicinity of Clifty Creek. Columbus' alternative to a treatment plant on Clifty Creek would be to construct a lift station and trunk sewer to the main Columbus sewage treatment plant on the East Fork of White River. The construction of a sewage treatment plan on Clifty Creek has been recommended by an engineering firm employed by the City of Columbus, at an estimated savings of $1,885,000 (1963 price levels), over the cost of a lift station and trunk sewer. Regardless which sewage treatment plan is adopted, additional dilution water will be required to obtain suitable quality of water for water supply for the City of Seymour, Indiana, located on the East Fork White River, downstream from the mouth of Clifty Creek.

The proposed plan for Clifty Creek Reservoir as contained herein does not provide specific storage for future water quality control due to the reservoir's limited storage capability and the greater need for storage for flood control purposes. Based on current data, operation of seasonal storage impounded to provide the summer recreation pool would not accommodate minimum releases of 20 cfs during the summer months of low inflow without loss of recreation benefits more than offsetting the benefits of flow regulation. Detailed study of this matter as a part of post-authorization planning is indicated. Future allocation

of reservoir space to storage for water quality control may also be possible through development of additional flood control storage in the vicinity to replace such storage at Clifty Creek.

c. Patoka. There is a need in the Patoka River Basin for additional stream flow to provide an adequate supply of water of quality suitable for municipal and industrial needs. The most critical area of need is between Jasper and Huntingburg.

The Public Health Service estimates that a minimum flow of 68 cfs will be required for water quality control and that an additional 8.4 cfs will be required for water supply at Jasper by the year 2010. These minimum flows should provide an acceptable quality for water supply for downstream communities except that further studies of acid mine wastes and oil field wastes entering the Patoka River from Winslow to below Princeton may indicate that a flow of 125 to 200 cfs would be required at Princeton to provide a safe source of public water supply at Princeton.

The plan for Patoka Reservoir as proposed herein includes water conservation storage of 167,500 acre-feet which is sufficient to sustain continuous concurrent releases of 68 cfs for water quality control as specified by the Public Health Service and 130 for water supply in satisfaction of needs expressed by the Indiana Flood Control and Water Resources Commission.

49. FEDERAL POWER COMMISSION

The Federal Power Commission has made a preliminary review of the hydroelectric power potentials of the three reservoir projects considered herein. Their studies indicate that at this time power is not feasible at either Lincoln or Patoka although there is some potential for power development in the foreseeable future. Pumped storage is a possibility at Patoka. Analysis of the power potential at Clifty Creek Reservoir indicates that power is not feasible now or in the foreseeable future. The complete letter reports of the Federal Power Commission are presented in Appendix F, Exhibit F-7.

50. SOUTHEASTERN POWER ADMINISTRATION

The Southeastern Power Administration, United States Department of the Interior, has been informed of the proposed plans of development for the reservoir projects considered herein. Since hydroelectric power is not a feasible project purpose for the reservoir projects considered, no expressions of interest have been received from this agency.

51. FOREST SERVICE

Plans of development for the reservoir projects considered herein have been furnished the Forest Service, United States Department of Agriculture, for their review. Administrative boundary of the Hoosier

National Forest, under jurisdiction of the Forest Service, includes all but a small part of the lands proposed for acquisition for Patoka Reservoir. The Forest Service is therefore preparing a report covering the impact of the Patoka Reservoir project upon the Hoosier National Forest. A letter presenting principal recommendations from the Forest Service's preliminary impact report and the District Engineer's reply thereto are included in Appendix F, Exhibit F-8. The District Engineer concurs in general with the views of the Forest Service except in connection with the recommendation that all lands not needed for flood control purposes be incorporated into the Hoosier National Forest system, it is believed that management of public use lands can best be determined in detailed design stages, if and when the project is authorized.

52. BUREAU OF PUBLIC ROADS

The required road relocations involved in the reservoir projects considered herein have been coordinated with the United States Department of Commerce, Bureau of Public Roads and suggestions as to road adjustments have been received from the Indiana and Illinois State Highway Departments.

53. WABASH VALLEY INTERSTATE COMMISSION

The Wabash Valley Interstate Commission has assisted in preparation of this report and is assisting in the Comprehensive Study through advice as to development needs and coordination of studies with State and local interests. The Wabash Valley Interstate Commission took particular interest in the potential Lincoln Reservoir in regard to storage for possible future water supply needs at Charleston and relationship of the project to drainage in the upper reach of the reservoir area. The three multi-purpose projects of this report are favored by the Commission as shown by expressions at the public hearings held in December 1963.

54. INDIANA FLOOD CONTROL AND WATER RESOURCES COMMISSION

The Commission and its staff has been a major cooperating agency with respect to formulation of the plan for Patoka Reservoir contained herein. In accordance with legislative authorities of 1959, 1961, and 1963 the Commission staff has performed extensive hydrologic studies for the project and supplementary foundation exploration, and the data developed have been used in preparation of this report. The Commission's interest in, and support of, the Patoka project is expressed in the statement of their chief engineer which is included in Appendix F, Exhibit F-10. Statements by the Commission presented at the public hearing on 11 December 1963 covering Clifty Creek indicated its strong support for the construction of this project.

55. DIVISION OF WATERWAYS, STATE OF ILLINOIS

In 1963 this agency published an Interim Report on the Embarrass River which included maps, channel cross-sections, and other basic data which have been very useful in studies of Lincoln Reservoir contained in this report. The agency endorses the Lincoln project and submitted testimony to that effect at the public hearing for the project.

56. OTHER STATE AGENCIES

Coordination with other State agencies has generally been effected through their Federal counterparts, previously indicated as cooperating in efforts connected with this Interim Report. State of Indiana agencies included in this coordination were: Division of Conservation, State Board of Health and the State Highway Commission. State of Illinois agencies were: Department of Public Works and Buildings, Department of Conservation, Department of Mines and Minerals and the Department of Public Health. Statements of approval by several of these agencies were received at the public hearings held in December 1963.

SECTION XI - DISCUSSION AND CONCLUSIONS

57. DISCUSSION.

This interim report deals with the development of effective plans for flood control, water conservation and allied purposes by means of reservoirs on Enbarrass River, Illinois, Clifty Creek, Indiana and Patoka River, Indiana, all situated in the Wabash River Basin. Extensive and recurrent flood damage has been, is now and will probably continue to be a major problem throughout the Wabash Basin. The three reservoirs considered in this report would afford a partial solution to the flood problems downstream, including the lower White, Wabash and Ohio Rivers. Lincoln Reservoir would control the runoff from 915 square miles or about 38 percent of the Embarrass River watershed. Clifty Creek Reservoir with a drainage area above the dam of 140 square miles would control the runoff from 70 percent of the Clifty Creek basin. The runoff of about 20 percent of the Patoka River watershed of 860 square miles would be controlled by the Patoka Reservoir. In total, the three reservoirs would control the runoff from 1,223 square miles of drainage area. This area when added to the combined drainage areas above Huntington, Salamonie, Mississinewa, Mansfield, Cagles Mill and Monroe Reservoirs, which are completed or under construction, and the two recommended but not authorized projects, Lafayette and Big Pine Reservoirs, would result in control of 5,353 square miles of the 33,100 square mile drainage area of the Wabash River basin. Allowing for control and accomplishments of the two previously recommended reservoirs the three reservoirs considered herein would increase drainage area control in the Wabash River basin from 12.5 to 16.2 percent and reduce the average annual flood damages in the areas of the Wabash Basin downstream from the three reservoirs from $7,443,000 to $5,580,000 based on December 1963 price levels. The Department of Agriculture findings indicate that the three reservoirs would not conflict with potential, proposed or completed projects under their Small Watershed program.

While the average precipitation and runoff in the Wabash River basin is ample to support a thriving agriculture and provide for the water needs, both consumptive and otherwise of a much larger population than is presently resident therein, seasonal distribution is not uniform and periods of low stream flow are not uncommon. There are present needs in some locations for water storage during periods of excess stream flow for later release to augment stream flow during periods of naturally low runoff in the interests of water supply and water quality control. And in the future, with increased population and water use, such needs may be expected to increase. Provisions for storage for water supply and water quality control have been included in the plans for two of the projects, Patoka and Lincoln Reservoirs, to meet estimated flow requirements for these needs. The State of Indiana, through the Indiana Flood Control and Water Resources Commission has expressed interest in control and administration of the proposed 167,500 acre-feet of conservation storage in Patoka Reservoir for water supply and incidental water quality control. However, since

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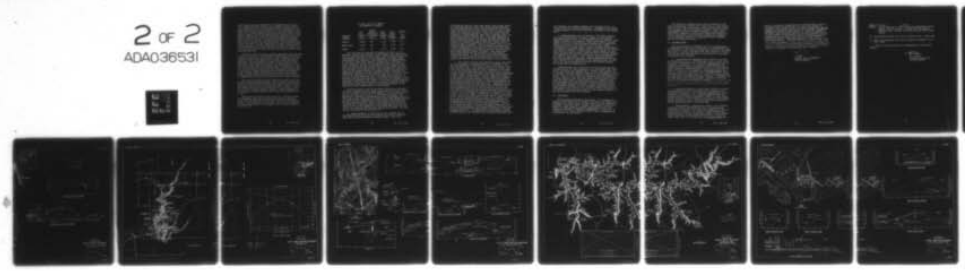

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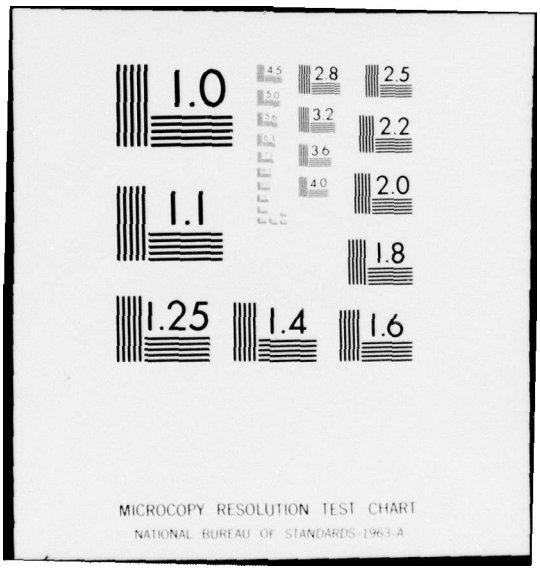
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reimbursement assurances furnished by the Commission defer the matter of payment for water quality control storage to later decision, costs allocated thereto are designated a Federal responsibility, and State reimbursement is presently limited to costs allocated to water supply only. Present needs for water supply and water quality control are not evident at Clifty Creek Reservoir, but future needs are foreseeable. However, due to the limited storage capability and the high value of flood control storage, the present plan does not include storage for these purposes. Consideration of additional potential sites in this vicinity and upstream may permit future reallocation of Clifty Creek storage to water quality control, water supply and other possible purposes. The City of Charleston, Illinois, has interest in water supply storage in Lincoln Reservoir for future use and has indicated that they would use water from the reservoir and reimburse costs associated therewith.

Demand for water-associated recreation opportunities has increased greatly in recent years. Such demands presently exist in the area of influence of each of the three reservoir sites considered herein and greatly increased future demands are foreseen. Patoka and Lincoln Reservoirs, with conservation pool areas of 8,880 and 6,760 acres respectively, have outstanding potential for satisfaction of recreation needs; Clifty Creek, with seasonal pool area of 919 acres, will also be useful in satisfying recreation needs. Recreation has, therefore, been included as a function in the multipurpose reservoir plans of this report. Initial construction would provide for the demand within a period of four years following the project construction. Future facilities would be developed over the life of the project as the demand increases and have been included in the economic analyses.

The projects considered in this report would result in the loss of some low quality stream fisheries. However, large reservoir pools would be created which would furnish great potential sport fisheries and provide for the needs of this type recreation. Losses to upland game habitat would result from construction of the projects. These losses could be somewhat offset by intensive wildlife management at the reservoir sites and additional public land made available by the projects.

The projects considered in this report are so scattered within the Wabash Basin that each project has been treated as operating alone. From the standpoint of costs and benefits, the projects considered in this report are well justified. As shown in the summary following, annual benefits exceed annual costs in ratios ranging from 1.6:1 to 2.2 :1.

SUMMARY OF COSTS AND BENEFITS
(IN THOUSANDS OF DOLLARS)

Reservoir project	Total construction cost	Annual operation maintenance replacement cost	Total annual economic cost	Total annual project benefits	Benefits to cost ratio
Lincoln	33,000	268	1,453	2,909	2.0:1
Clifty Creek	15,900	200	726	1,167	1.6:1
Patoka	24,000	311	1,013	2,232	2.2:1

Public hearings have been held to determine the views of local interests, ranging from individuals to governmental units, with respect to the projects considered in this report. Project information has also been furnished separately to various individuals and groups through correspondence and conferences. The preponderance of opinion received as a result of these local contacts, including that of the States concerned, members of Congress who have expressed views, municipal and county governments, and the vast majority of private groups and individuals, has favored the three projects and cited urgent needs for them. Most residents of the reservoir areas under consideration, however, are opposed to the projects because of intangible losses associated with displacement, and the belief that payments received for lands and damages would not be sufficient to replace the interests they now possess. In the case of Lincoln Reservoir, also, some landholders adjacent to the reservoir area have filed objections in the belief that drainage of their lands would be impaired by the project. In the case of Clifty Creek some supporters of the project have pointed out the early need for conservation storage on this stream, which is not presently proposed, in the interests of water quality control and water supply.

Potential reservoir sites in the Wabash River Basin are extremely limited in comparison to total storage space required to secure control of runoff for flood control and other purposes. For this reason development of such sites as are found to be individually justified, will generally be compatible with comprehensive basin development, except in cases where direct competition for essentially the same benefits requires concurrent or prior consideration of any alternate project potentials. The three proposed projects covered in this report would not preclude any other water resources projects, would provide the best early steps toward solution of the urgent needs of the Wabash River Basin and would fit into any comprehensive basin plan subsequently developed. The three projects are discussed individually below:

a. Lincoln Reservoir is located at the best available site in the Embarrass River Basin from the standpoint of cost and accomplishments and would afford maximum practicable storage at this site.

Sites upstream would have less flood control effectiveness because of reduced drainage area control and reduced storage capability. Sites downstream would have less storage capability, due to topography, and would be more costly to develop, due to inferior topographic and foundation conditions. Major flood control benefits creditable to Lincoln Reservoir would occur in Embarrass River valley starting just below the dam site. Flood stage reductions on Wabash and Ohio Rivers would be smaller, although significant in value on the Wabash River. Lincoln Reservoir would not usurp the potential for further reductions on these main streams that are needed and might be provided in part by reservoirs still to be considered on other tributaries. The only potential alternative to reservoir impoundment for equivalent, or even lesser flood protection, of the downstream areas along the Embarrass would be levees, which might aggregate 200 miles in length. Such construction would be more costly than the reservoir and of questionable economic feasibility. It would also make reservoir development necessary to meet present and projected future needs for water supply, water quality control and other purposes, less attractive.

b. With regard to Clifty Creek Reservoir, storage sites feasible of development are especially limited in tributaries of the East Fork White River. Feasibility of sites in tributaries to the south of Clifty Creek is very questionable, due to cavernous limestone strata in valley floors and walls; tributaries to the north and west of Clifty Creek offer poor site potentials due to lack of adequate storage capability afforded by the very shallow entrenchment of these streams. Flood control is sorely needed in the middle reaches of East Fork White River. Previous studies have indicated the feasibility of levee protection at only two sites downstream within range of significant effects of Clifty Creek Reservoir; viz, the authorized projects for Levee Units 2 and 3 (presently in "deferred" status) on the East Fork White River. Clifty Creek Reservoir will provide limited flood control benefits for these and other downstream areas but will not eliminate the need nor materially affect justification for possible subsequent additional flood protection by the authorized levee projects or other means in these reaches. Also, water supply is already greatly needed in some areas of this sub-basin and future need for water quality control is indicated. Clifty Creek Reservoir will fulfill only a portion of the above needs and further consideration will be given during the Comprehensive Basin Study to possible limited development of some of the potential reservoir sites on other tributaries. However, due to above-noted needs and limited development potentials, it is apparent that development of the one good tributary site found feasible and justified on Clifty Creek should be an element of any comprehensive basin plan. In selecting the specific project location on Clifty Creek, it was determined that no suitable downstream sites

were available, and feasible alternate sites upstream would be less effective and less favorable economically. Development of the maximum storage potential of the Clifty Creek site is provided by the proposed plan.

c. Patoka Reservoir would be located at the closest available site upstream from the City of Jasper, Indiana, and will provide essentially complete relief to that community from the extensive flood damage to which it is now subject. Flood control benefits will also extend to the town of Winslow further downstream and to agricultural lands of the valley of the Patoka River for its entire length. Topographically, the Patoka site is uniquely favorable to development of storage for essentially complete control of runoff from its drainage area, making it possible to provide large storage capacity for water supply and water quality control, which the State of Indiana considers very important to the future of this region, as well as ample storage for effective flood control. Also, with its three major branches, many small embayments and generally wooded hillsides around the shore line, together with the large area of the conservation pool, the reservoir will provide an especially valuable and attractive resource for recreational development and use.

Patoka Reservoir will not meet all flood control and other water resource needs in the Patoka sub-basin as it will control only 20 percent of the Patoka River drainage area. Further study therefore will be required of potential additional improvements in downstream portions of the basin, including possible reservoirs on other tributaries of the Patoka. However, none of these are considered potential alternatives to Patoka Reservoir since they would provide benefits mainly to areas other than those served by Patoka Reservoir or as needed to supplement the limited flood stage reductions afforded by Patoka for areas at considerable distances downstream. Previous studies of possible flood protection measures by levees and channel improvements in downstream areas on the Patoka have not indicated economic feasibility of such projects, except for levees near the mouth required primarily for protection against Wabash River flooding.

58. CONCLUSIONS.

From the studies presented in this report, it is concluded that storage of flood waters for the purpose of reducing flood damages along Embarrass River, Clifty Creek and Patoka River, and areas downstream therefrom, is urgently needed. Further, that storage of water for the creation of lakes affording recreation opportunity on these three streams and provision of storage for augmentation of low flow in the interests of water supply and water quality control on Embarrass and Patoka Rivers, are also needed.

The reservoirs considered herein would be responsive to the needs outlined above, benefits which would accrue to them would exceed the cost of their development, and the allocated cost of each project purpose would be economically justified. Public opinion preponderantly favors the projects considered, benefits would be sufficiently widespread to justify major Federal participation in project construction, and the projects considered are compatible with and essential elements of a comprehensive plan of development for the Wabash River basin.

59. RECOMMENDATIONS.

The District Engineer recommends that the following projects be authorized for construction as elements of the Comprehensive Plan for development of the water and related land resources of the Wabash River Basin, in general conformance with plans contained in this report and with such modifications as in the discretion of the Chief of Engineers may be advisable.

a. Lincoln Reservoir, Embarrass River, Illinois, at an estimated construction cost of $33,000,000 and with an estimated annual maintenance and operation cost of $268,000, provided that, prior to construction, responsible local interests furnish satisfactory assurances that no channel encroachments tending to reduce present channel capacities of Embarrass River, between the dam site and the mouth of the river, will be permitted, and provided further that, prior to construction, responsible local interests agree to pay the allocated initial and annual costs for water supply storage (except for replacement of existing water supply storage), in accordance with the Water Supply Act of 1958 as amended. Allocated construction costs for water supply are presently estimated at 0.75 percent of the project construction cost or $249,000, which amount includes allowance for allocated annual operation, maintenance and major replacement costs.

b. Clifty Creek Reservoir, Clifty Creek, Indiana, at an estimated construction cost of $15,900,000 with an estimated annual maintenance and operation cost of $200,000, provided that, prior to construction, responsible local interests furnish satisfactory assurances that no channel encroachments tending to reduce present channel capacities of Clifty Creek and the East Fork of White River, between the dam site and the junction of East Fork of White River with the Muscatatuck River, will be permitted.

c. Patoka Reservoir, Patoka River, Indiana, at an estimated construction cost of $24,000,000 and with an estimated annual maintenance and operation cost of $311,000, provided that, prior to construction, responsible local interests furnish satisfactory assurances that no channel encroachments tending to reduce present channel capacities of Patoka River between the dam site and the mouth of the river, will be permitted, and provided further that,

prior to construction, responsible local interests agree to pay the allocated initial and annual costs for water supply storage, in accordance with the Water Supply Act of 1958 as amended; and provided further that responsible local interests be authorized, dependent upon their future affirmative decision, to acquire and operate the storage provided for water quality control upon agreement to pay the allocated initial and annual costs therefor, and upon agreement to operate that storage to meet objectives as set forth by the U. S. Public Health Service. Allocated construction costs for water supply are presently estimated at 15.24 percent of the project construction cost, or $3,658,000; and allocated annual operation, maintenance, and replacement costs are presently estimated at 3 percent of the project operation, maintenance, and replacement costs, or $10,000.

W. ROPER
Colonel, Corps of Engineers
District Engineer

ORDED-P (2 Jan 64) 1st Ind
SUBJECT: Interim Report No.2 - Wabash River Basin Comprehensive Study; Indiana, Illinois and Ohio; covering reservoir sites on Embarrass River, Illinois, and Clifty Creek and Patoka River, Indiana

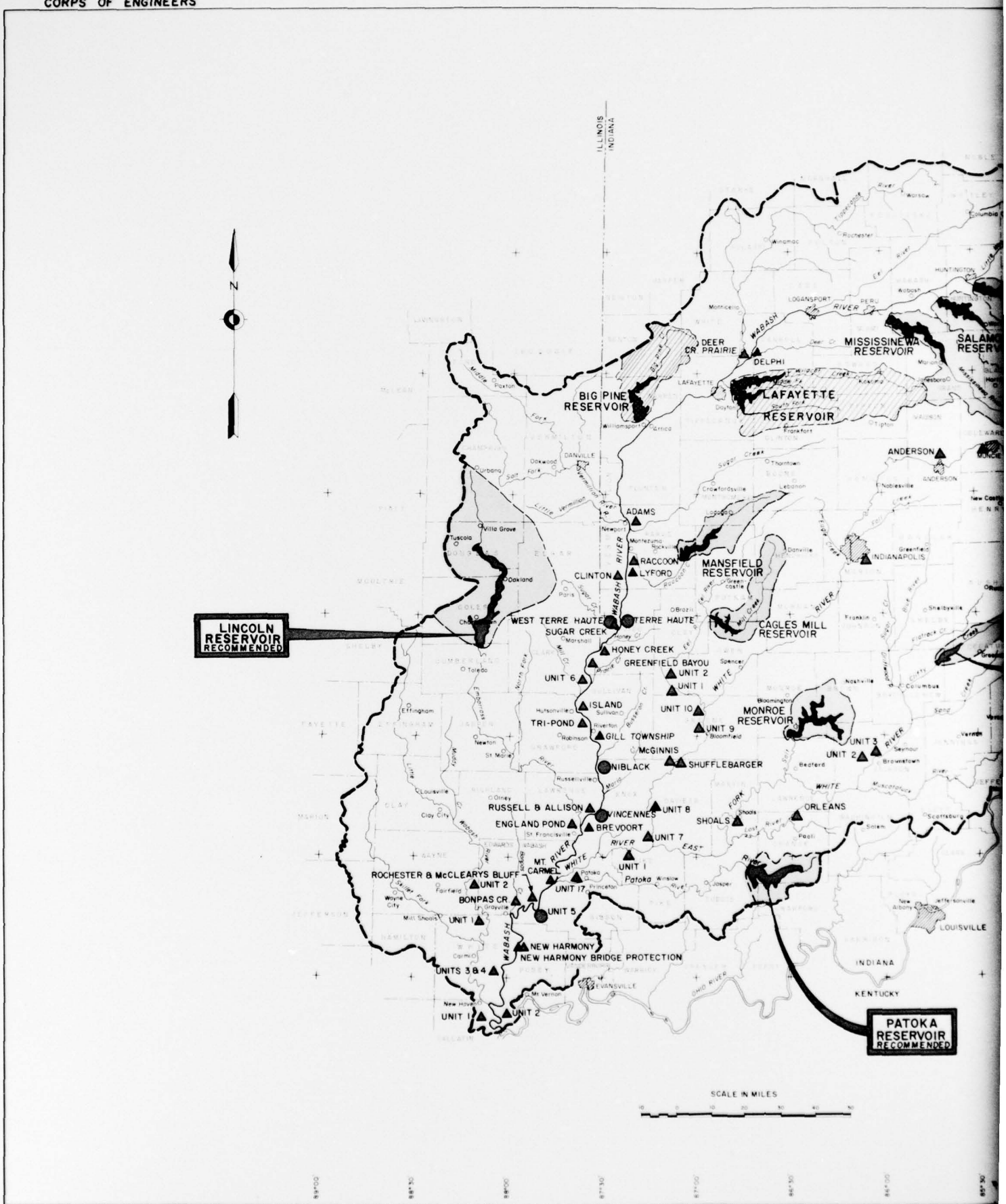
U.S. Army Engineer Division, Ohio River, Cincinnati, Ohio 1 April 1964

TO: The Board of Engineers for Rivers and Harbors, Washington 25, D.C.
ATTN: ENGBR

I concur in the conclusions and recommendations of the District Engineer.

W. P. LEBER
Brigadier General, USA
Division Engineer

CORPS OF ENGINEERS



U. S. ARMY

VICINITY MAP
SCALE IN MILES

LEGEND

	Completed	Under Construction	Authorized Not Started	Recommended Not Authorized Interim Report ⇐ 1	Reservoir Recommended Interim Report ⇐ 2
Reservoir	▲	●	▲	▲	▲
Local Protection	▲	●	▲		

SCALE IN MILES
20 30 40 50

WABASH RIVER BASIN
OHIO, INDIANA AND ILLINOIS

GENERAL MAP

SCALES AS SHOWN

LOUISVILLE DISTRICT JAN. 1964

SUBMITTED: John J. Bruner

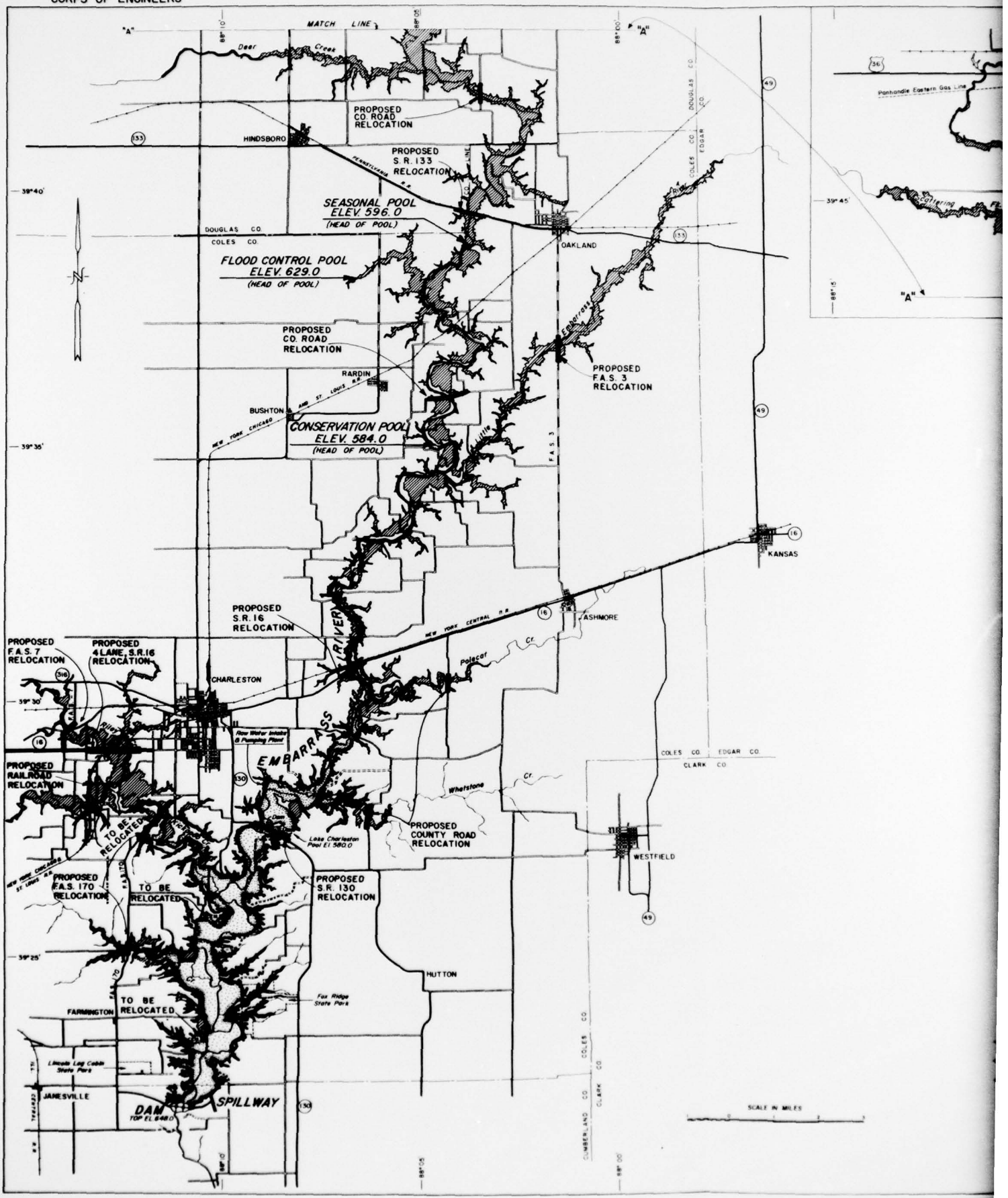
APPROVED: R. C. Hangen

APPROVED: R. Pope
COL. CORPS OF ENGINEERS
DISTRICT ENGINEER

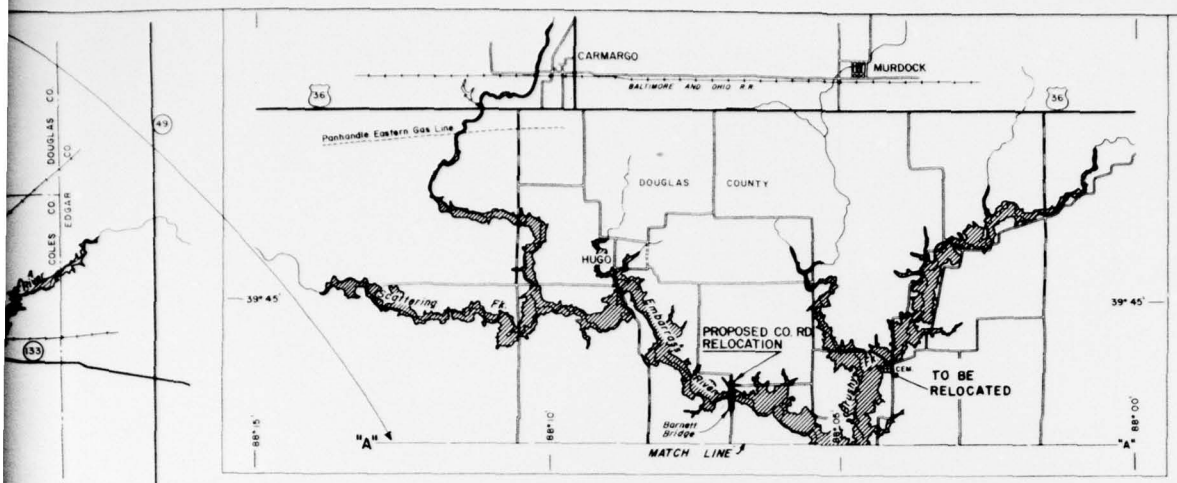
TRANSMITTED WITH REPORT DATED JANUARY 1964

PLATE 1

CORPS OF ENGINEERS



U. S. ARMY



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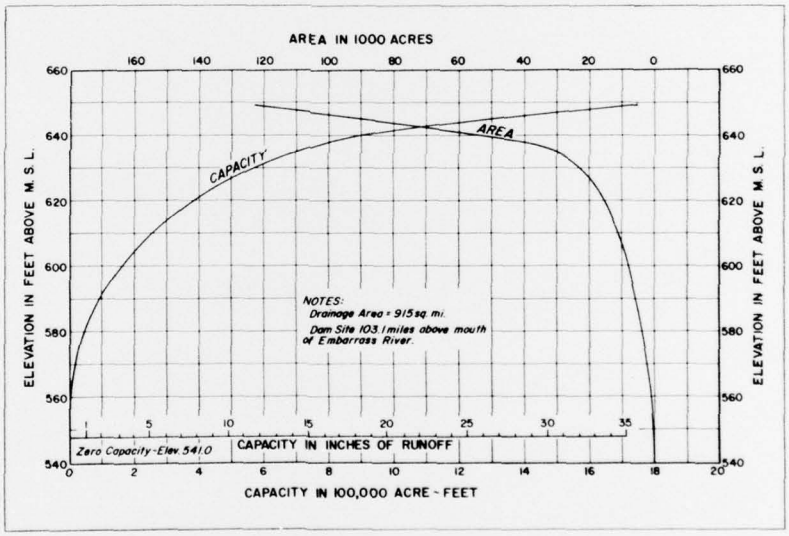
VICINITY MAP

SCALE IN MILES



LEGEND

- FLOOD CONTROL POOL ELEV. 629.0
- SEASONAL POOL ELEV. 596.0
- CONSERVATION POOL ELEV. 584.0
  MINIMUM POOL ELEV. 582.4

SCALE IN MILES

WABASH RIVER BASIN
INDIANA, ILLINOIS AND OHIO

EMBARRASS RIVER

LINCOLN DAM & RESERVOIR

RESERVOIR AREA
AREA AND CAPACITY CURVES

SCALES AS SHOWN

LOUISVILLE DISTRICT — JANUARY 1964

SUBMITTED: Joe T. Barnes

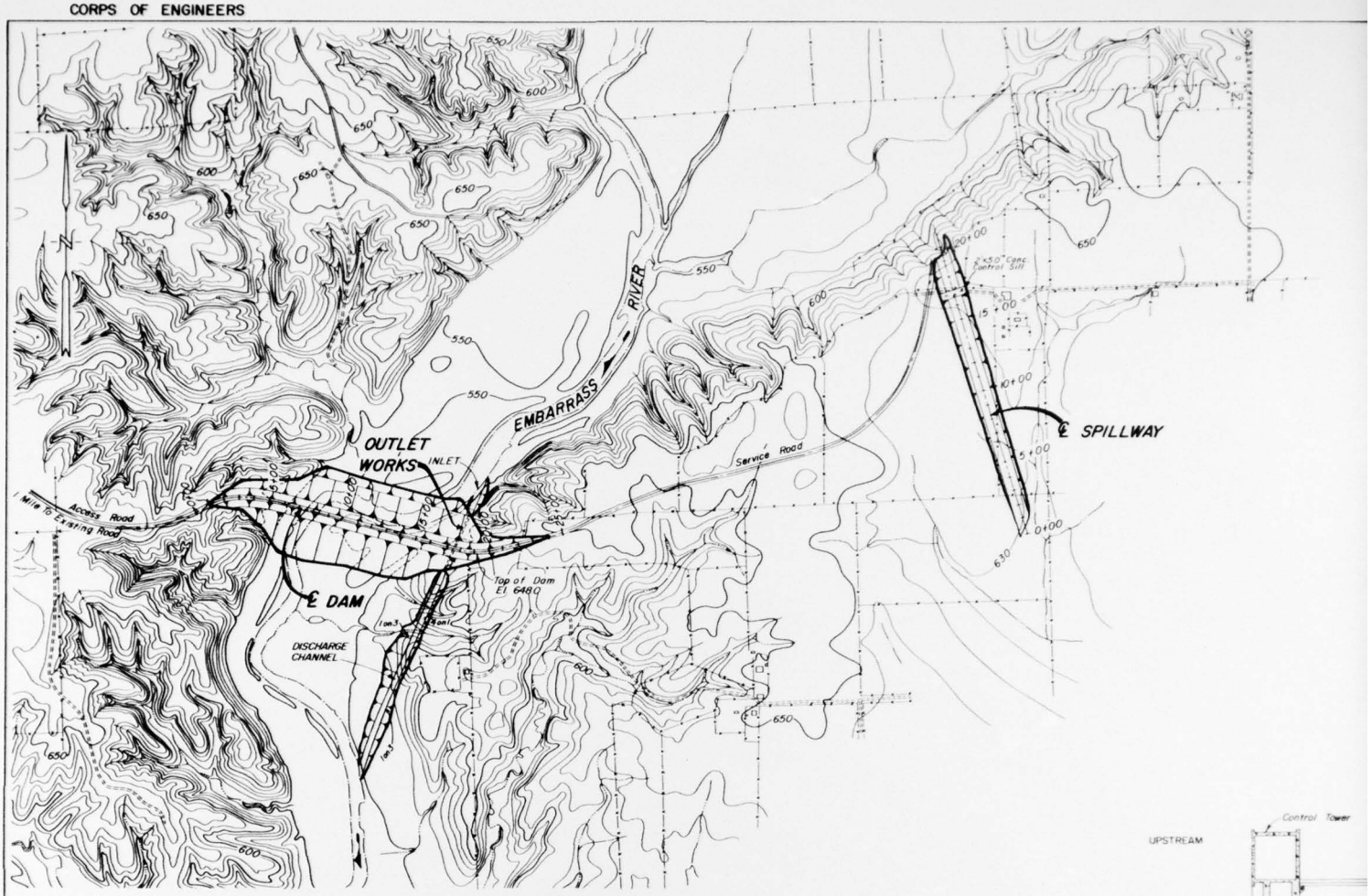
APPROVED: R. H. Hayes

APPROVED: W. Row
COL. CORPS OF ENGINEERS
DISTRICT ENGINEER

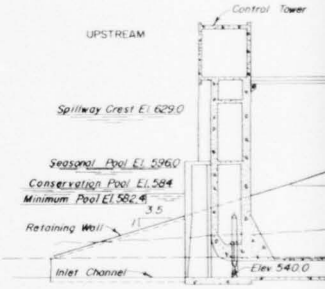
TRANSMITTED WITH REPORT DATED JANUARY 1964

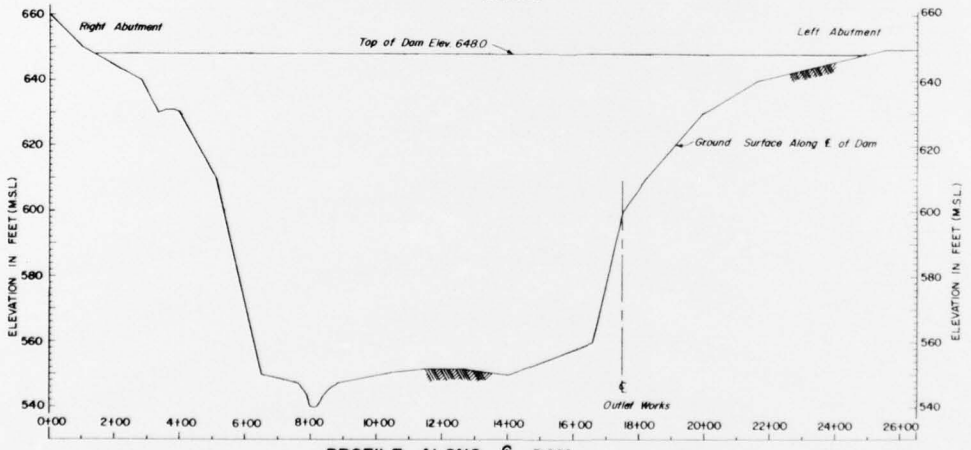
PLATE 2

CORPS OF ENGINEERS

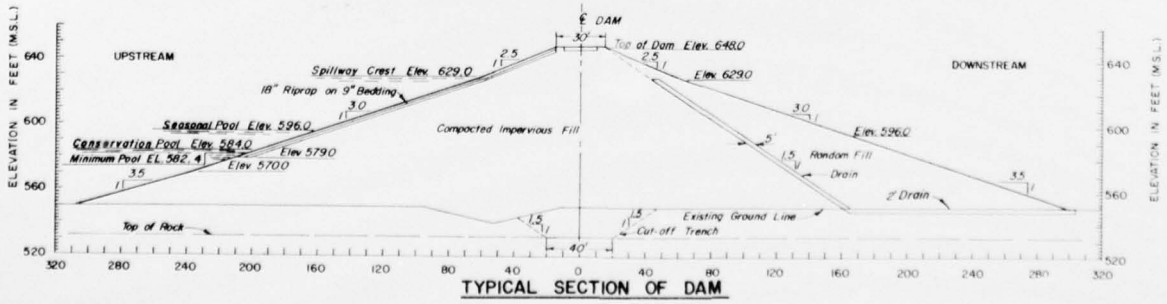


PLAN



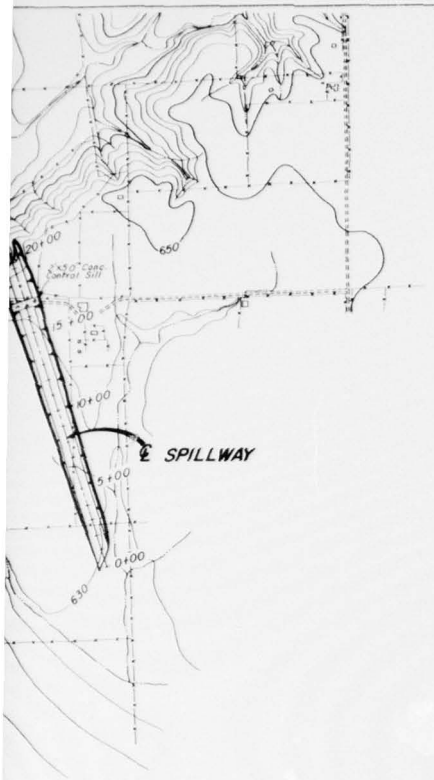


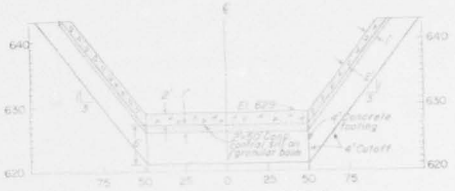
PROFILE ALONG ℄ DAM



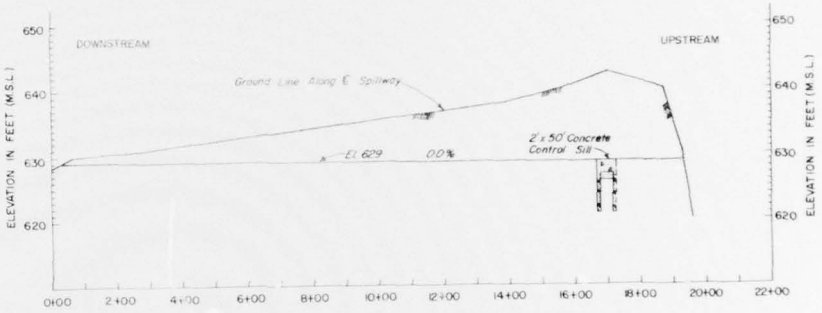
TYPICAL SECTION OF DAM

U.S. ARMY

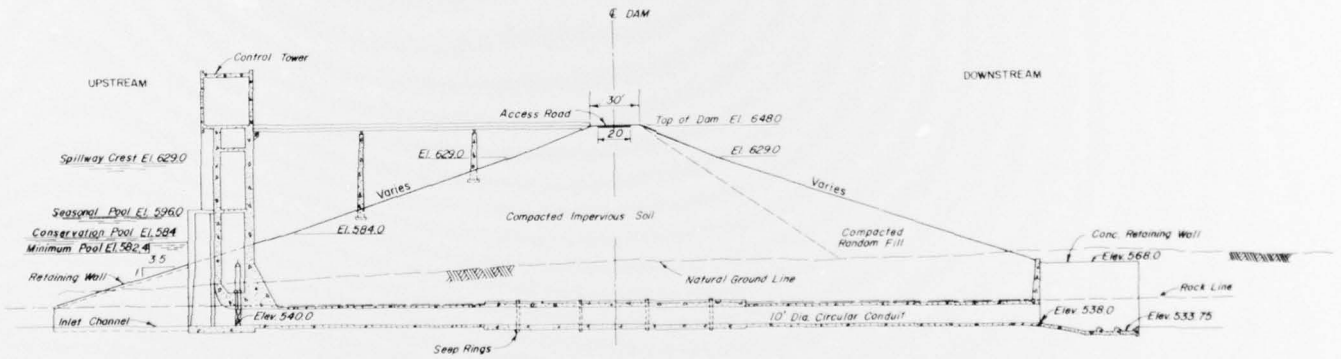




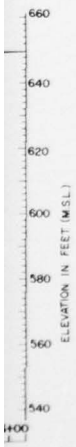
SPILLWAY SECTION
AT CONTROL SILL

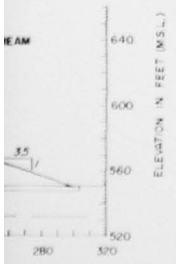


PROFILE ALONG ℄ OF SPILLWAY



SECTION ALONG ℄ OF OUTLET WORKS





WABASH RIVER BASIN
INDIANA, ILLINOIS AND OHIO

EMBARRASS RIVER

LINCOLN DAM & RESERVOIR

PLAN PROFILE & SECTIONS

SCALES AS SHOWN

LOUISVILLE DISTRICT — JANUARY 1964

SUBMITTED: John J. Bruce

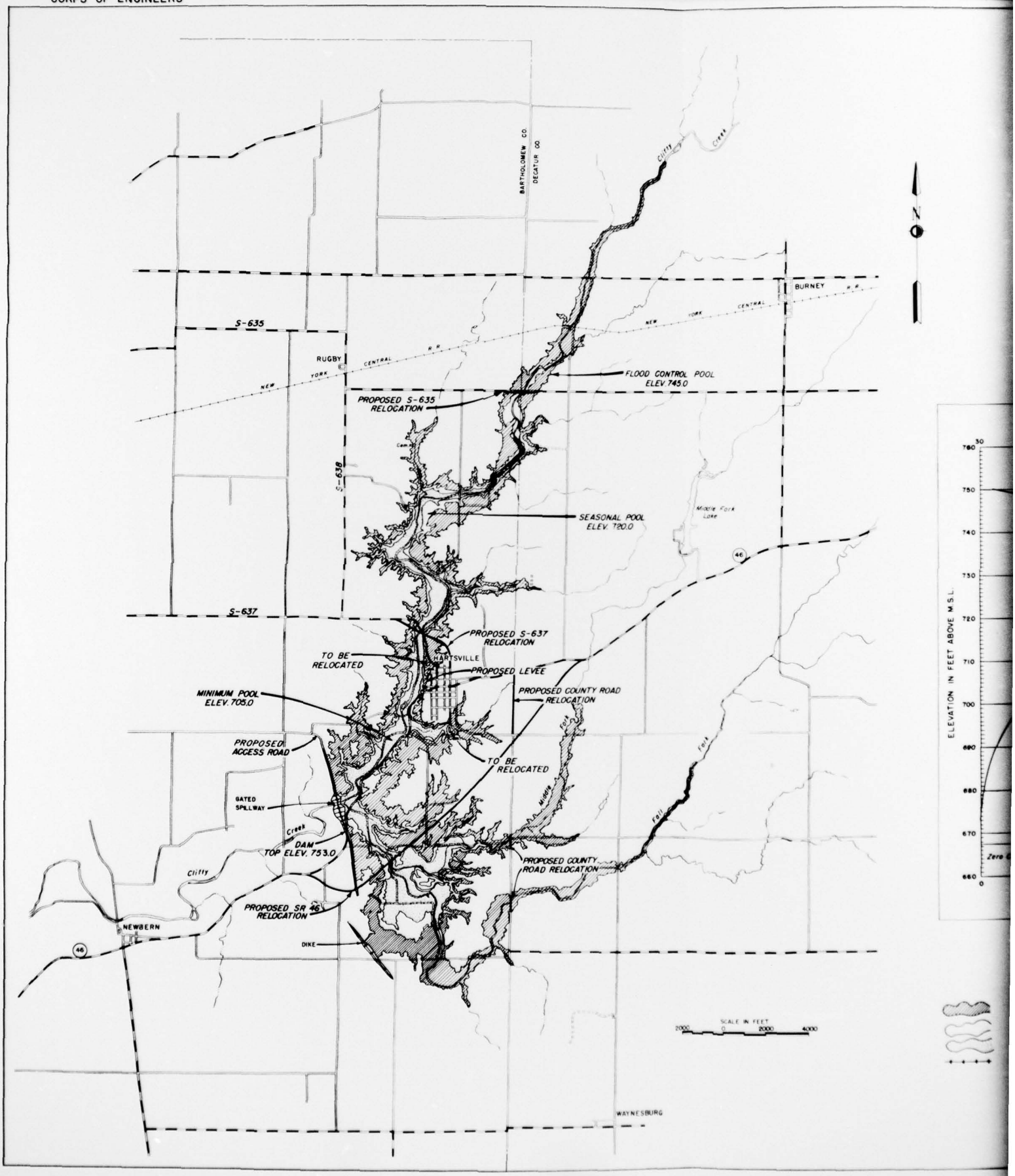
APPROVED: R. H. Hoge

APPROVED: W. Rice
COL., CORPS OF ENGINEERS
DISTRICT ENGINEER

TRANSMITTED WITH REPORT DATED JANUARY 1964

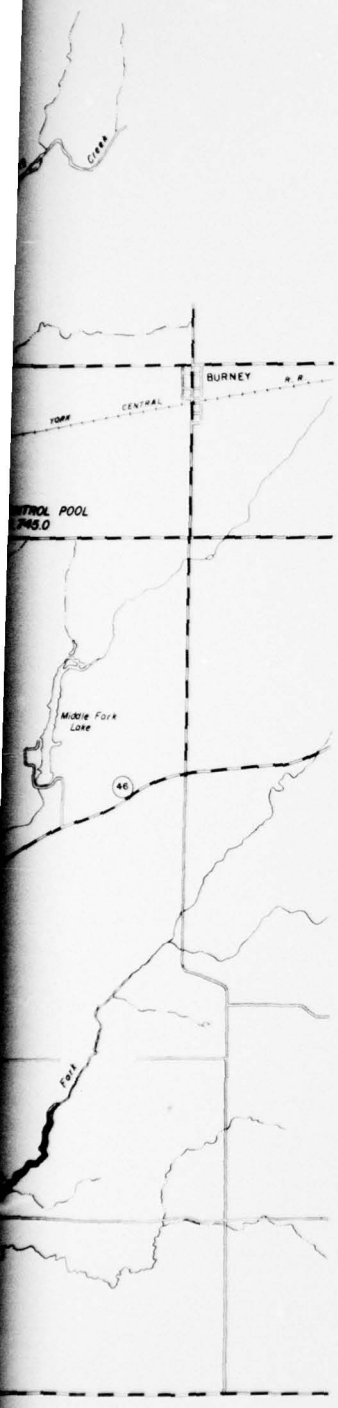
PLATE 3

CORPS OF ENGINEERS



VICINITY MAP

SCALE IN MILES



AREA & CAPACITY CURVES

LEGEND

FLOOD CONTROL POOL ELEV. 745.0'

SEASONAL POOL ELEV. 720.0'

MINIMUM POOL ELEV. 705.0'

LEVEE

SCALE IN FEET

2000 0 2000 4000

WABASH RIVER BASIN

INDIANA, ILLINOIS AND OHIO

CLIFTY CREEK

CLIFTY CREEK DAM AND RESERVOIR

RESERVOIR MAP

SCALES AS SHOWN

LOUISVILLE DISTRICT JANUARY 1964

SUBMITTED: John J. Bruce

APPROVED

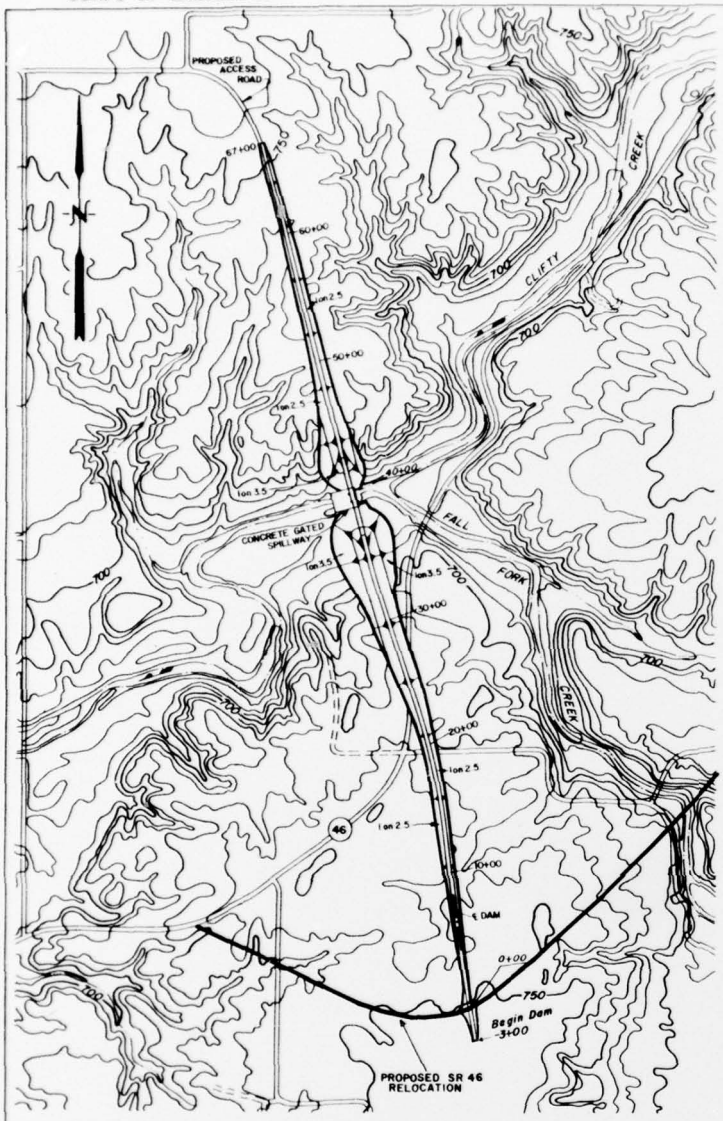
APPROVED

COL. CORPS OF ENGINEERS
DISTRICT ENGINEERS

TRANSMITTED WITH REPORT DATED JANUARY 1964

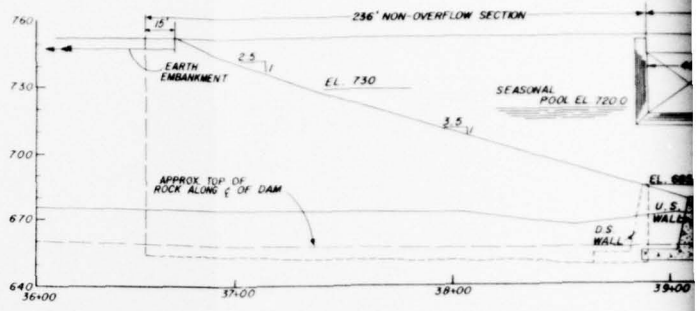
PLATE 4

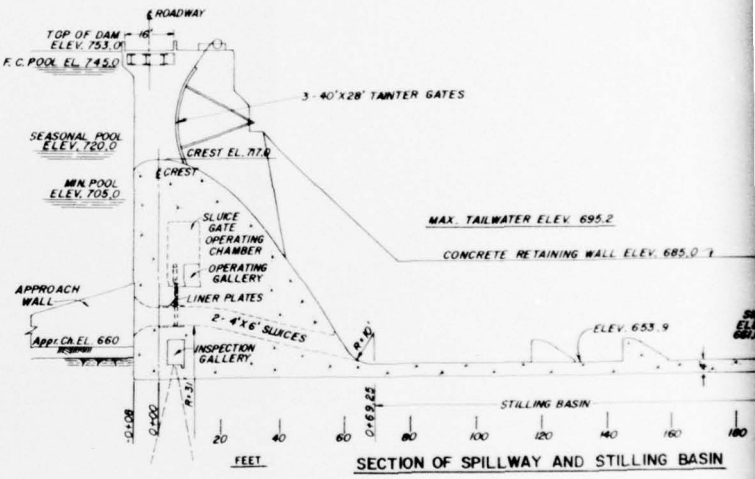
CORPS OF ENGINEERS



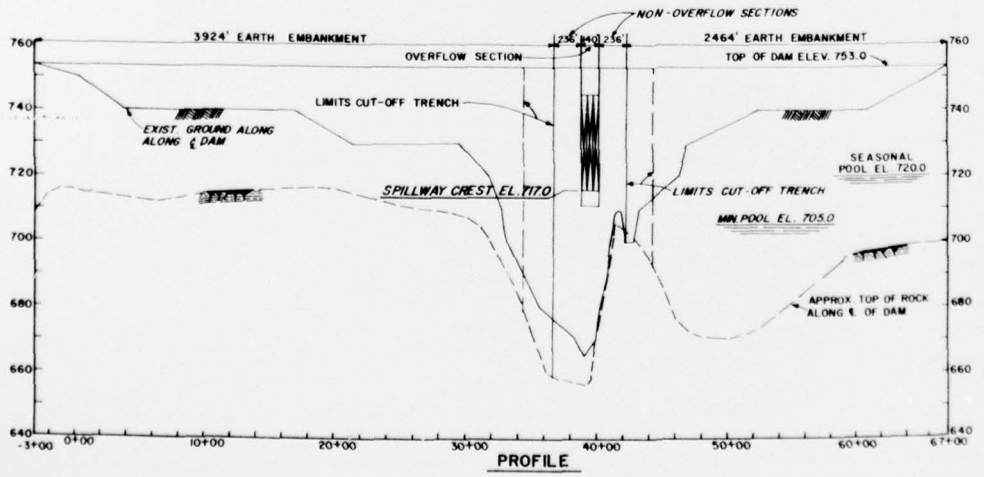
PLAN

400 0 400 800 FEET

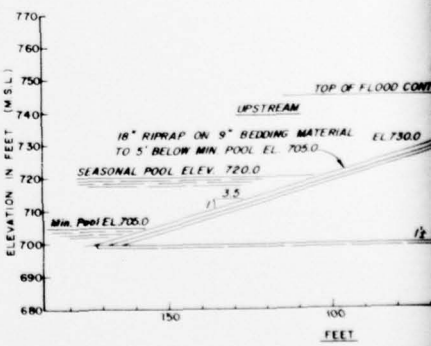


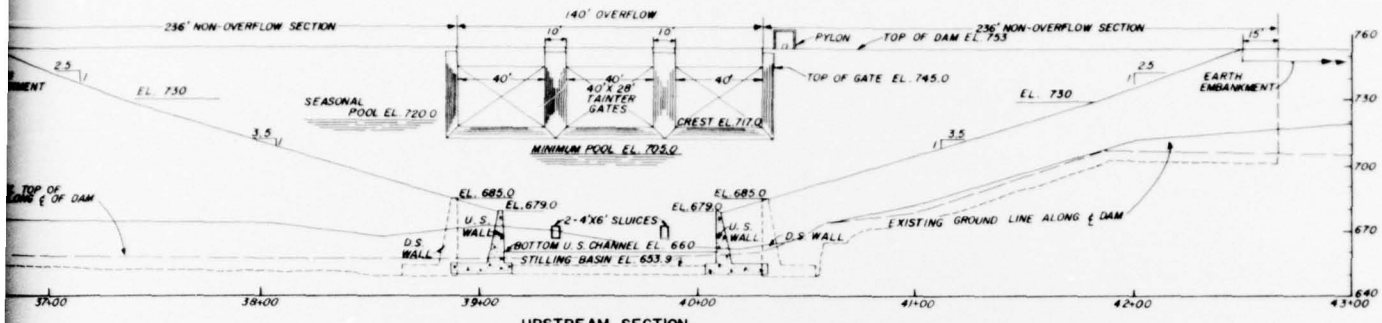


SECTION OF SPILLWAY AND STILLING BASIN

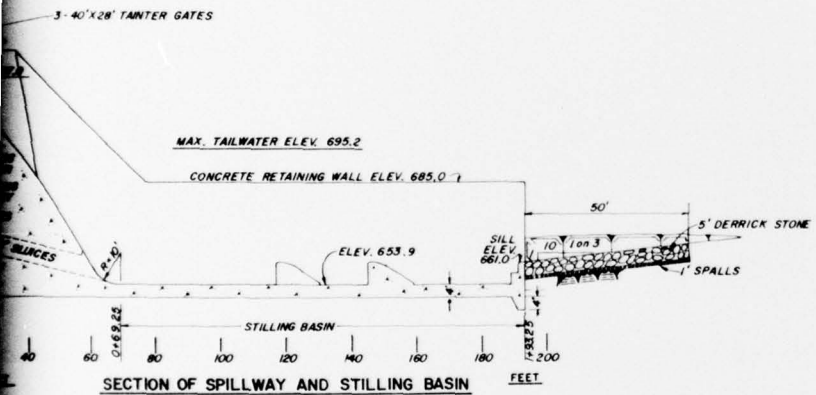


PROFILE

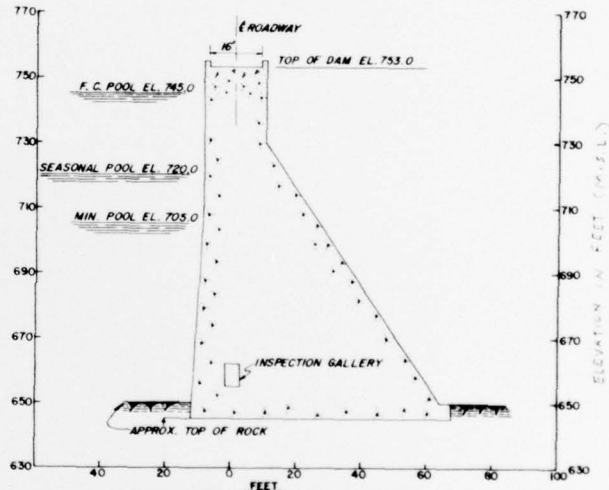




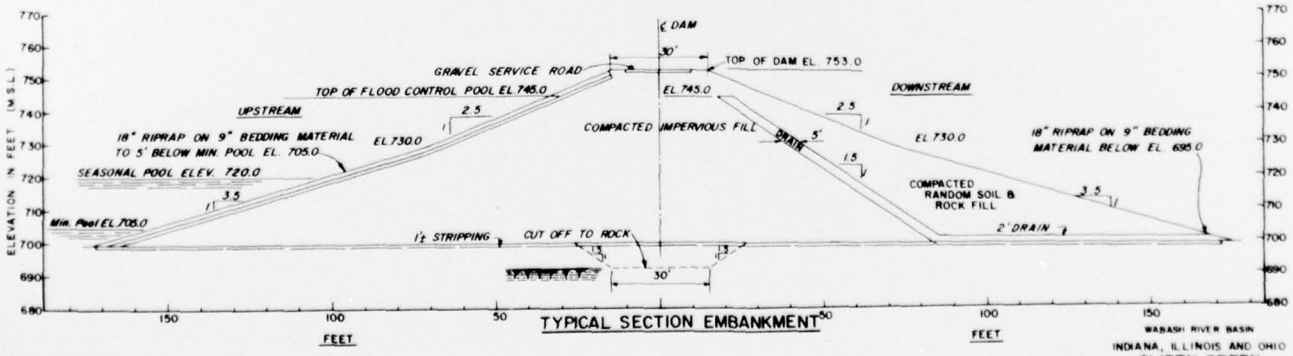
UPSTREAM SECTION



SECTION OF SPILLWAY AND STILLING BASIN



TYPICAL NON-OVERFLOW SECTION



TYPICAL SECTION EMBANKMENT

WABASH RIVER BASIN
INDIANA, ILLINOIS AND OHIO
CLIFTY CREEK

CLIFTY CREEK DAM AND RESERVOIR
PLAN, PROFILE & SECTIONS

SCALES AS SHOWN

LOUISVILLE DISTRICT — JANUARY 1964

SUBMITTED: [signature]

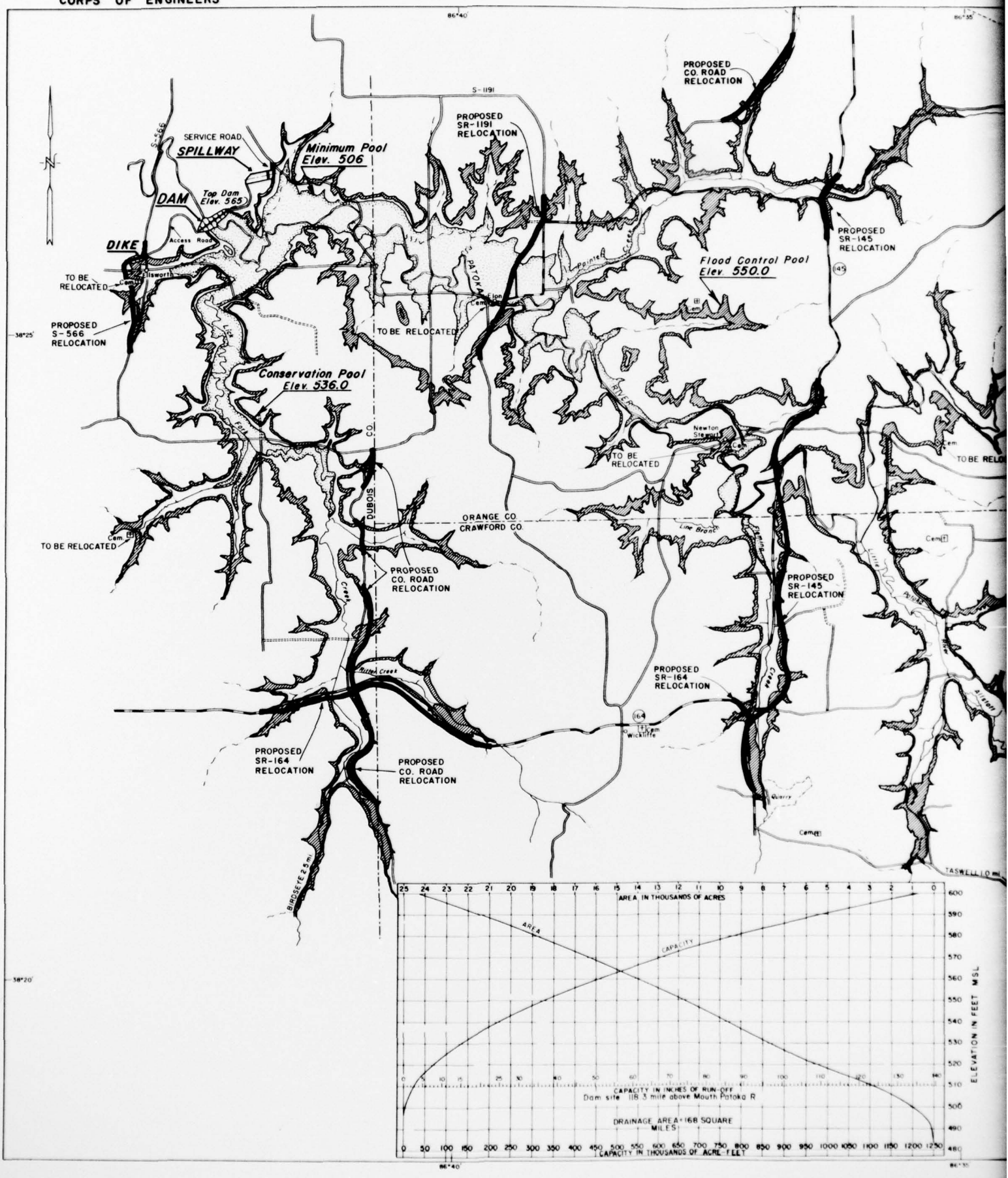
APPROVED: R. H. Harper

APPROVED: [signature]
COL., CORPS OF ENGINEERS
DISTRICT ENGINEER

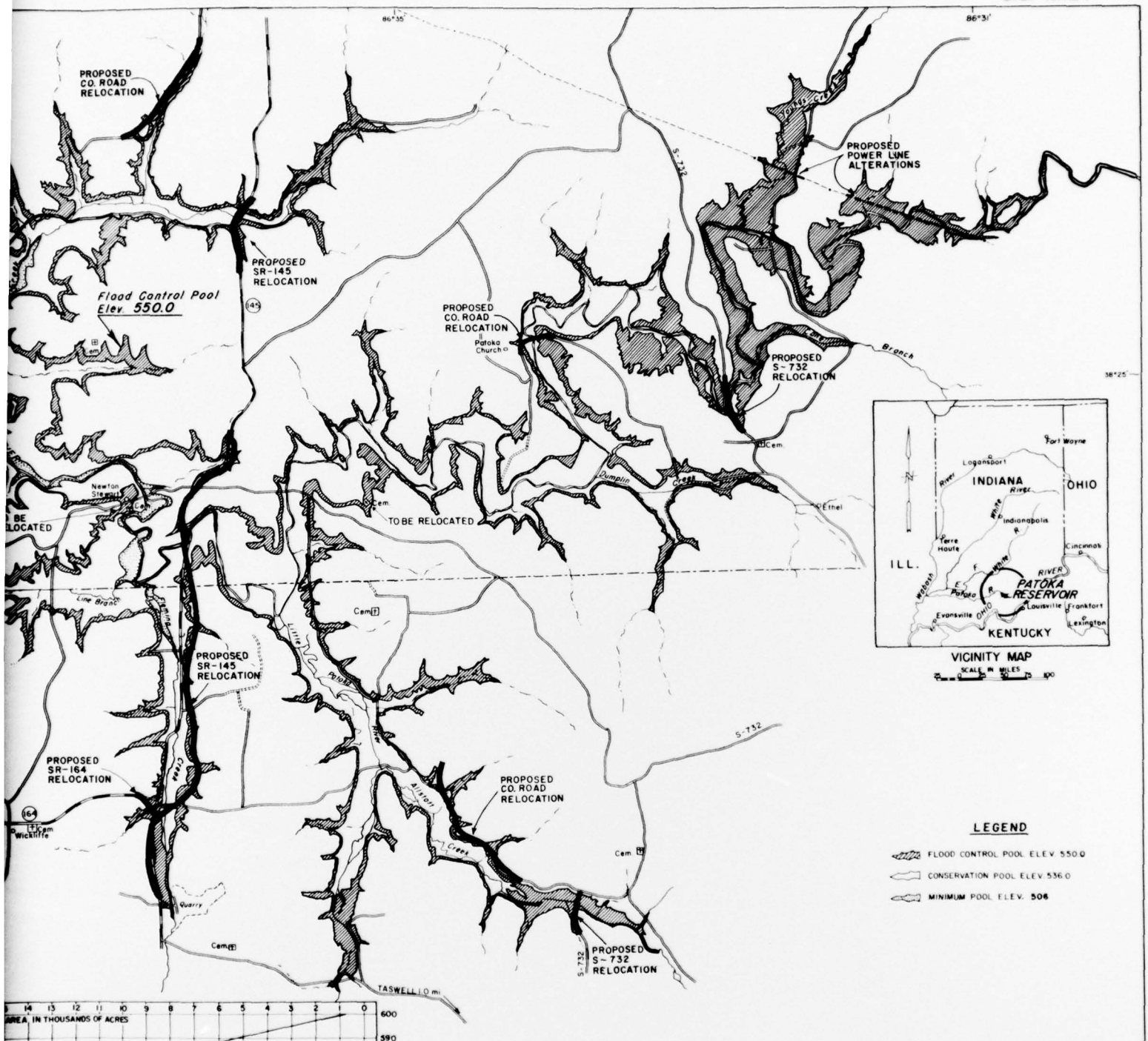
TRANSMITTED WITH REPORT DATED JANUARY 1964

PLATE 5

CORPS OF ENGINEERS



U.S. ARMY

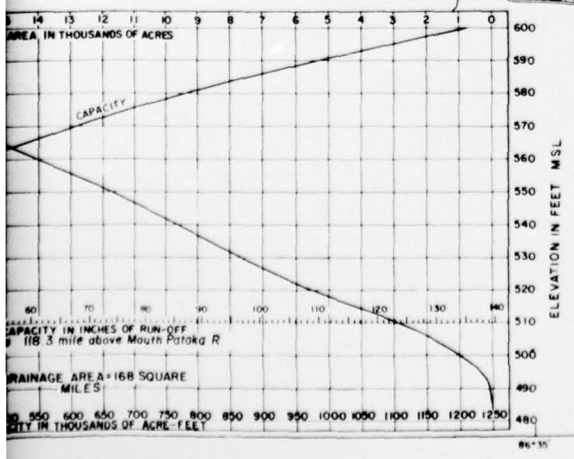


VICINITY MAP

SCALE IN MILES 0 50 100

LEGEND

- FLOOD CONTROL POOL ELEV. 550.0
- CONSERVATION POOL ELEV. 536.0
- MINIMUM POOL ELEV. 506



SCALE IN FEET

2000 0 2000 4000

WABASH RIVER BASIN

INDIANA, ILLINOIS AND OHIO

PATOKA RIVER

PATOKA DAM & RESERVOIR

RESERVOIR AREA AREA & CAPACITY CURVES

SCALES AS SHOWN

LOUISVILLE DISTRICT JANUARY 1964

SUBMITTED: John J. Bruner

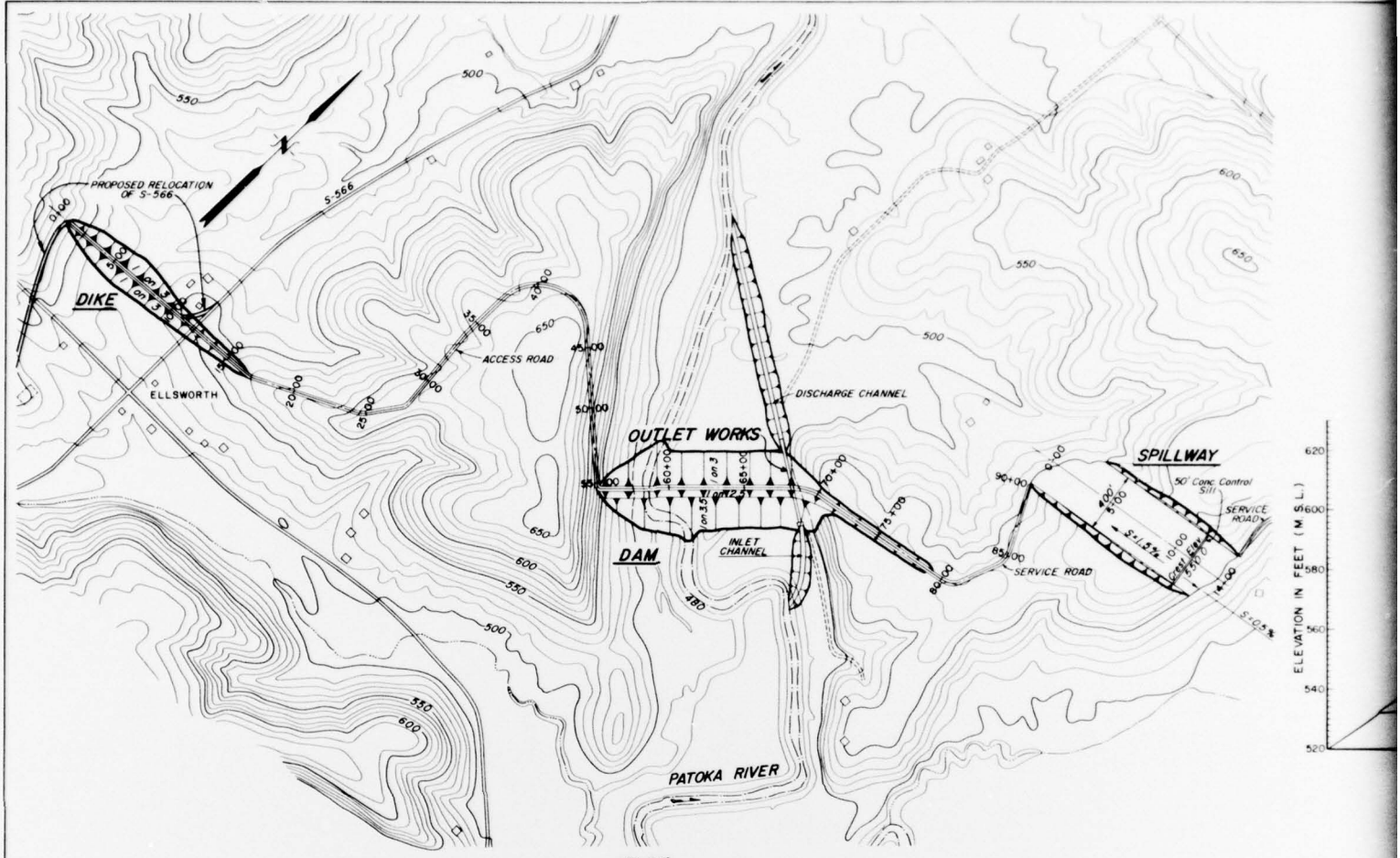
APPROVED: C. H. Harper

APPROVED: COL. CORPS OF ENGINEERS DISTRICT ENGINEERS

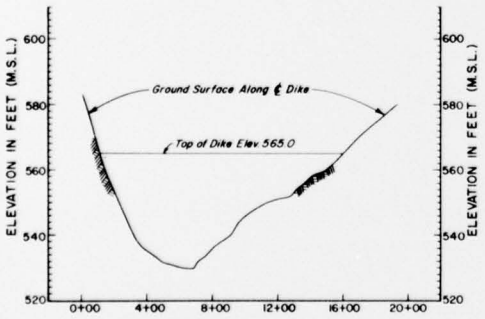
TRANSMITTED WITH REPORT DATED JANUARY 1964

PLATE 6

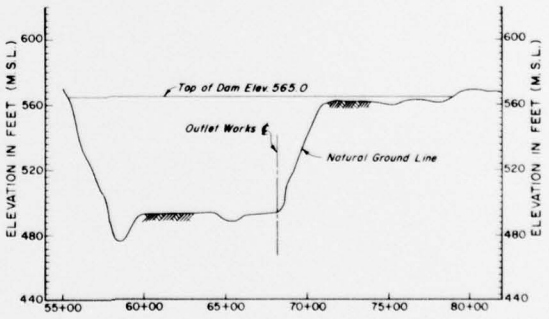
CORPS OF ENGINEERS



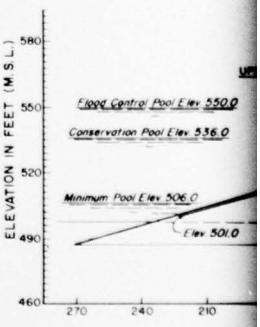
PLAN
SCALE IN FEET

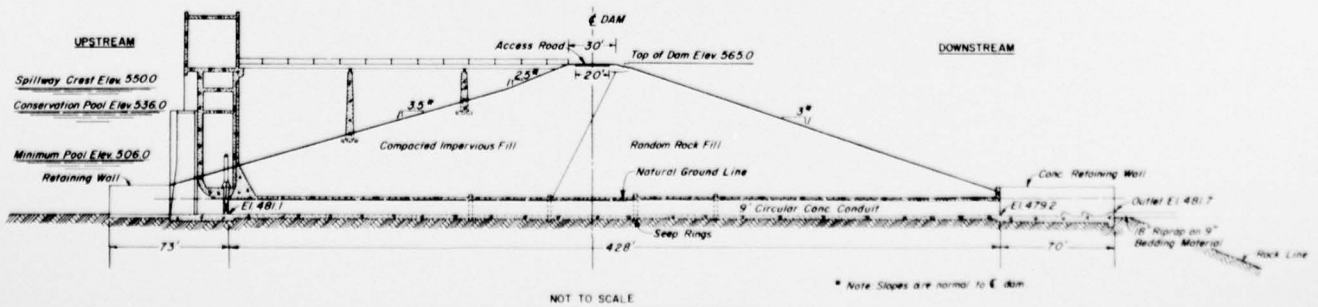


PROFILE ALONG ℄ OF DIKE



PROFILE ALONG ℄ OF DAM

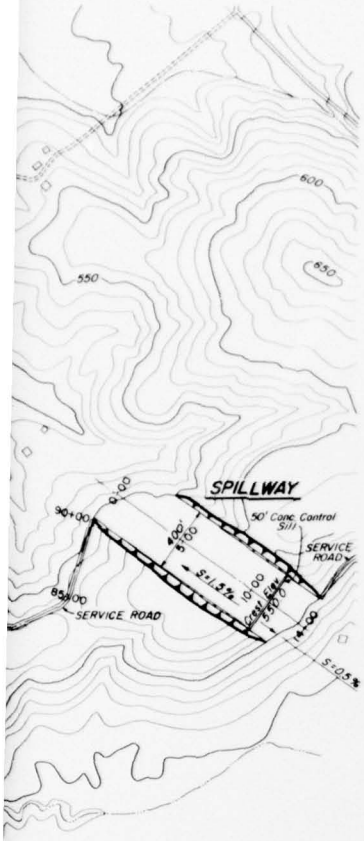


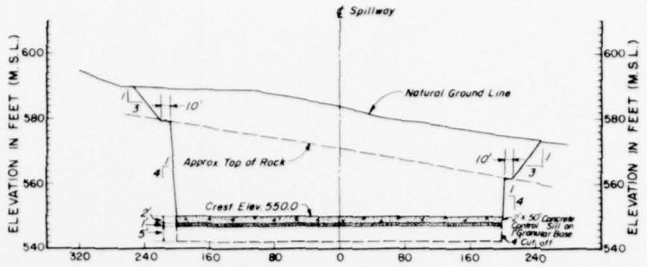


* Note: Slopes are normal to ℄ dam

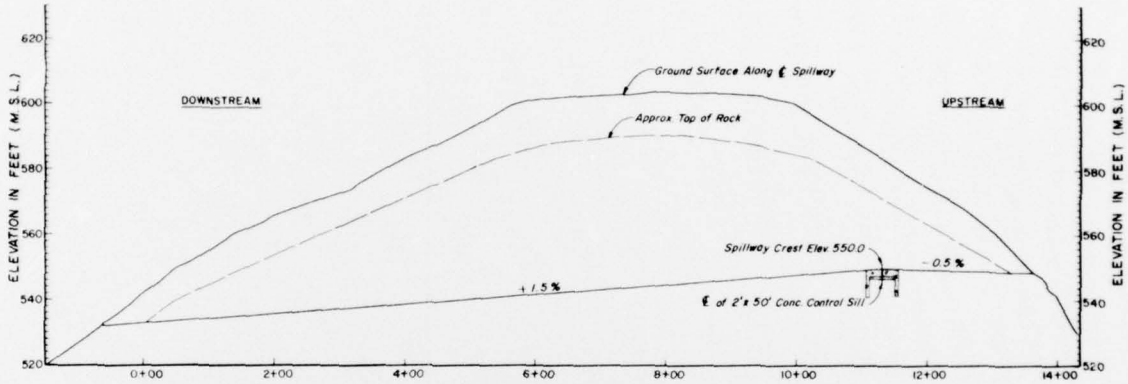
SECTION ALONG ℄ OF OUTLET WORKS

U. S. ARMY

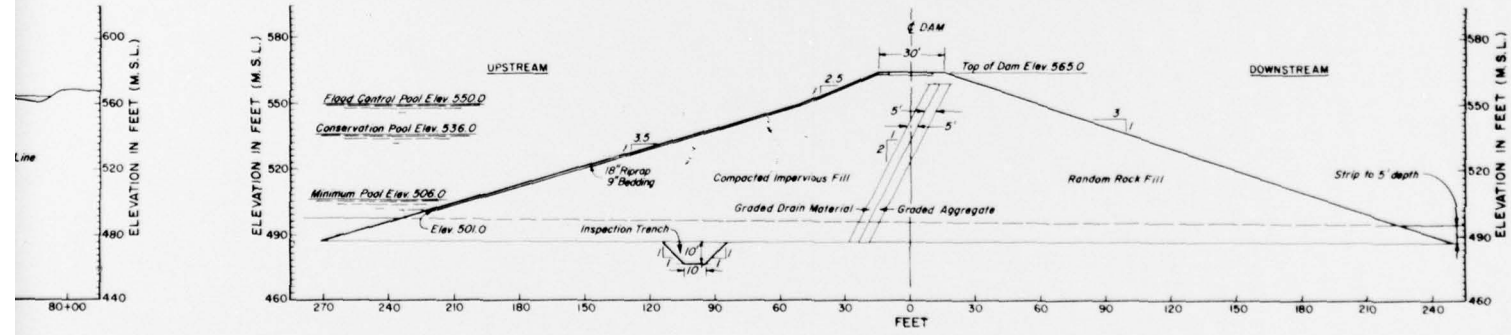




SPILLWAY SECTION ON CREST

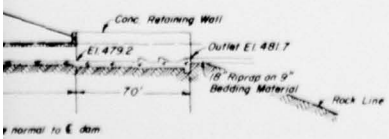


PROFILE ALONG ℄ OF SPILLWAY



TYPICAL SECTION OF DAM

DOWNSTREAM



normal to ℄ dam

WABASH RIVER BASIN
INDIANA, ILLINOIS AND OHIO
PATOKA RIVER

PATOKA DAM AND RESERVOIR
PLAN, PROFILE & SECTIONS

SCALES AS SHOWN

LOUISVILLE DISTRICT JANUARY 1964

SUBMITTED: John T. Bowen

APPROVED: R. H. Hayes

APPROVED:
COL., CORPS OF ENGINEERS
DISTRICT ENGINEER

TRANSMITTED WITH REPORT DATED JANUARY 1964

PLATE 7